SANTA CLARA VALLEY WATER DISTRICT

HYDROLOGY

Documentation
for the
Central Flood Control Zone

Prepared by

A. D. Saah, P.E.

Under the Direction of

Managements of Water Supply Planning
and
Design and Construction Units

5

July 1978

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TABLE OF CONTENTS

Page

INTRODUCTION iii

SUMMARY OF METHODS AND PROCEDURES 1
General 1
Regional Regression Analysis 2
Gaged and Ungaged Locations 3
Techniques Used for Developing Flood Hydrograph 3
Regulated Watersheds 4
Urban Hydrology 5
Upper 80% Confidence Limits 6
Previous Studies and Coordinated Results 6
Further Information 7
Acknowledgements 8

GUADALUPE RIVER HYDROLOGY 1-3
Recommended 1% Design Flows 1-52
Recommended 10% Design Flows 1-55

LOS GATOS CREEK HYDROLOGY 2-2
Recommended 1% Design Flows 2-24
Recommended 10% Design Flows 2-25

REFERENCES 2-27

Los Gatos Creek Hydrology

Los Gatos Creek

INTRODUCTION

This report summarizes the work completed on the hydrology within the Santa Clara Valley Water District's Central Flood Control Zone. Presented in the report are recommended design flows for Guadalupe River and Los Gatos Creek and each of their respective tributaries. They are divided into several hydrologic studies, each containing a table of contents, general information about the physical and hydro-meterological features of the basin, and a discussion of the procedures followed. This last item includes the analysis of recorded data as well as recorded and reconstituted data. It also includes a comparative analysis of the regional and site specific statistics.

The choice of the final design flows is based on findings from the above results. It is the intent of this report, as well as other similar reports, to present a documentation of the hydrologic assumptions made together with the steps taken in the mathematical calculations. Each creek was originally treated separately. Inasmuch as the study has been combined in terms of flood control zones, some redundancy is to be expected.

The following is a list of the tributaries analyzed in these studies:

Guadalupe River Hydrology

Alamitos Creek
Calero Creek
Canoas Creek
Golf Creek
Greystone Creek
Guadalupe Creek
Guadalupe River
Los Gatos Creek
Randol Creek
Ross Creek
Santa Teresa Creek

SUMMARY OF METHODS AND PROCEDURES

General

The District has established its flood protection criterion for watershed areas greater than four square miles based on flows which has a 1% chance of being equaled or exceeded in any one year. For watershed areas between one and four square miles the criterion is the 2% flood and for watershed areas between 360 acres and one square mile it is the 4% flood.

The accompanying reports represent the 1977-78 update of the design flood flows for use in the design of flood control facilities in Santa Clara County. They present documentation for the calculation of the 1% and 10% design flood flows. Other design values (2% and 4%) are not presented herein; they could be obtained upon request. These values were calculated using the District's methods and procedures as augmented and modified by the recommendations of the panel of expert hydrologists* convened to review the methods in 1976 (Ref. 8). It was assumed in the derivation of these design flows that the channel system is free from major constrictions or significant flood storage (reservoirs are handled separately) and that the floodwaters at the design level are completely contained within channel banks or relatively narrow floodway limits.

The District's method of determining the design peaks and volumes of floods utilized all available sources of information to derive the most accurate values possible. In general, this method began with the use of Regional Regression Equations to compute peaks and volumes. These peaks and volumes were compared with the results of an analysis of reliable recorded streamflow data when such exist. The values were also compared with the results of a rainfall-runoff model before the final "design flow" classification is given. Where design flows are presently affected by reservoirs or by urbanization, special analyses accounting for their effects were performed. Finally, the design flows were compared with the results of other studies and with previously determined design flows. The results of such comparison are useful to further define the design values.

---

*The panel members were Leo Beard, Dave Dawdy, Neil Grigg, Douglas L. James and Vujica Yevjevich. Their report, "Review of Basic Hydrology Methodology for Flood Control" Santa Clara Valley Water District, 1976, is available from the District library.

Hydrographs were derived utilizing the Corps of Engineers' standard project storm and the Clark Synthetic Unit Hydrograph technique. The peaks and volumes of these hydrographs were then adjusted to agree with those values derived from regional or local statistics. The flood hydrographs obtained this way are considered representative for use in the design of most flood control facilities. However, where flood traps (small volume peak skimmers) are being considered, a sensitivity analysis of the design relative to hydrograph shape should be conducted.

Following is a more detailed disucssion of these methods. Full documentation of the analyis of each stream is available in separate reports.

Regional Regression Analysis

The backbone of the District's hydrology is the application of the Regional Regression Equations (1976) for the determination of flood peaks and volumes. These equations were obtained by analyzing recorded streamflow data (peak flows and their respective volumes) from stations within and outside the District. The data were correlated, expanded, and the resultant statistics adjusted to obtain the dependent variables (mean, standard deviation, and 1% flow). These statistics were then regressed to the physical characteristics of their respective basins (independent variables) by means of a mathematical process called Multiple Linear Regression. The regression equations chosen had minimal standard errors of estimates and maximum determination coefficients. These equations are applicable to all unurbanized locations within the District to generate statistics for the determination of design flood peaks and volumes.

Gaged and Ungaged Locations

At gaged locations the statistics from the regression equations were compared with the site-specific statistics obtained from recorded data when such data were usable. The statistics from recorded data were obtained using the methods presented in the Water Resources Council Bulletin #17 (Ref. 2). If there were significant differences between the regional and site-specific results, then new statistics (weighted with respect to their respective standard errors) were calculated. These statistics, together with a Pearson Type III distribution a -0.6 regional skew coefficient or a weighted one, were used to determine the frequency regime.

At ungaged and rural locations, the results of the regression equations are considered to provide the best available information and, hence, are to be used for analysis and design.

Techniques Used for Developing Flood Hydrographs

Pattern runoff hydrographs are obtained from rainfall using Clark's Synthetic Unit Hydrograph method (as developed by the Corps of Engineers' HEC-1 computer program). This rainfall runoff transformation involves the determination of loss rates, synthetic unit hydrograph parameters, spatial distribution of rainfall over the watershed and temporal distributions of rainfall rates within one storm. The first two items are usually obtained from projections of optimized results of recorded rainfall and its respective runoff data. The averaging of rainfall over the basin is usually done by the regular Theissen weighing operations. The temporal distribution is determined generally by using the Corps of Engineers' Standard Project Storm for Northern California.

If the peaks and volumes of the pattern hydrographs obtained are drastically different from the regional or site-specific results, then the reasons were investigated and, if justified, further adjustments were made. In this study, the rainfall-runoff-generated peaks and volumes are found to generally agree with regional or statistical values when average rainfall and area configurations were present. To avoid the uncertainties inherent in the rainfall-runoff transformation, the peaks and volumes generated from this transformation are balanced by regional values.

The balanced hydrographs obtained above are then combined with other hydrographs and routed downstream. The routing was done using linear methods (e.g., Muskingum by computing k when x = 0) if routing through channel system, or nonlinear methods (modified Pulse) if significant storage is available.

Rainfall distribution, time of concentration and the various routing operations are the items that define the shape of pattern hydrographs, with rainfall distribution being the foremost. The effect of the shape of these hydrographs, given constant peaks and volumes, may become significant when flow trapping is being considered as a flood protection measure. An in-depth analysis of the shape was not attempted as a part of this work.

Regulated Watersheds

In regulated watersheds, regulated by reservoirs, the design flows are assumed as inflows to the reservoirs. The initial storage levels of the reservoirs that coincide with the design flows of certain frequencies are computed from the stage-duration frequency (S.D.F.) analysis of daily recorded reservoir volumes. The Corps of Engineers' Coincidental Frequency Analysis (discussed in Leo Beard's "Statistical Methods") procedures were used to solve this compounded probability problem. At most reservoirs, the S.D.F. curves after 1968 were used because, since that time, the reservoirs have retained more water in storage longer to enhance recreation.

Urban Hydrology

The above procedures are applicable mainly to rural watersheds. For urban watersheds, the methodology changes and the regional regression equations do not apply.

Urban hydrology deals with the effects due to two major changes in the watershed, namely:

1. Increased imperviousness
2. Channelization

The increase in imperviousness is caused by rooftops, streets, parking lots, driveways, and other man-made ground surface cover. Channelization includes the flow of water in gutters, storm drains, improved channels, etc. An increase in the imperviousness tends to reduce the loss rates and increase the runoff volumes and peaks, while channelization may either increase or decrease the peaks. It depends on the magnitude of the flood and the storage-discharge capacity of the various channels or storm drain systems that carry the flood.

To determine the effect of increased imperviousness, the urban area of every watershed was divided into subareas tributary to the major storm drains. These subareas are then transformed into equivalent rectangular subareas where the length is equal to the length of an equivalent street. The ratio of imperviousness (which is a measure of land use) is then used to subdivide this equivalent subarea into two sub-subareas of pervious and impervious parts.

In order to calculate the separate inflow hydrographs from the two sub-subareas, the unit hydrograph procedure was employed using separate times of concentration for both the pervious and impervious parts. The routing coefficient is calculated from the length and width of these areas. The loss rates, which are the third set of parameters needed for the computation of the one percent flood hydrograph, are assumed to be 30 percent for the pervious part and five percent for the impervious part. Since most of the floodwater from urban areas is conveyed to flood control channels by the storm drain system, these hydrographs are routed through the storm drain system utilizing the modified Pulse routing method. This routing requires storage-discharge curves for the system of streets, gutters, manholes, and storm drains. Two actual urban areas, one of low-density residential and another of high-density residential and commercial, were used to develop equivalent generalized storage facilities and storage-discharge curves. The resultant curves were transformed to reflect unit areas, and then compared with each other. Since the two curves are very similar, an average smooth curve was chosen and used.

Because most of the urban area in Santa Clara Valley is in the flatland and similar storm drain design criteria were used throughout, it is assumed that the unit storage-discharge curve that was obtained from the above study is applicable to all the urban areas in the Valley.

The above method is detailed in a paper presented before the National Symposium on Urban Hydrology in 1976.

Upper 80 Percent Confidence Limits

As a District policy, the upper 80 percent confidence value for the 1% design flow rate is used as one input to define freeboard criteria. It is defined as the value at which there is a 90 percent chance that the design flow is equal to less than the given value. It relates to the standard errors associated with the statistical inferences of information about populations from very limited samples. These values are calculated using the Non-Central Student "t" Distribution as shown in the Water Resources Council Bulletin #17.

Previous Studies and Coordinated Results

As a part of the design flood flow determination procedure, all available hydrologic analyses done on any watershed were reviewed and considered.

These previous analyses were sometimes the result of an in-house effort and other times the result of efforts of other agencies.

Because of the nature of random events, especially in the case of small samples, the results obtained from previous analysis were not necessarily congruent with the new values. Therefore, an in-depth search of the adequacy of the various results and methods involved was done.

As a result of this study, some of the adopted values were supported not only by District-developed methods and techniques but also by those of the Corps of Engineers and others.

Further Information

The attached information is only a summary report of that available. Additional information, available upon request from the Hydrologic Library, is listed below:

1. Hydrographs, either plotted or numerical, at all locations.
2. Runoff from intermediate areas such as urban runoff.
3. Recorded streamflow data at most gaged locations.
4. Stochastically estimated data at most gaged stations.
5. A full spectrum of statistical analysis of the above data which include the investigation of outliers, the incorporation of historic flows, and the adjustment of statistics and probabilities.
6. Statistical analysis of rainfall data on all gaged locations.
7. Complete descriptions and documentation of computations done for other streams in the County.
8. Other supporting documents of the methods like the 1976 Panel of Experts Report, the 1976 Regional Regression Study, Paper on Urban Hydrology and Reports by Zone, discussing the hydrology in detail.

ACKNOWLEDGEMENTS

E. Watson, Division Engineer, was wery instrumental in directing the work and reviewing the report. E. C. So and Morgan Kolyn helped in preparing parts of this study.

Guadalupe River

Determination of Design Flows

CONTENTS

Page

Background Information 1-3

Historic Events 1-6

Discussion of Procedures 1-9

- Basin Characteristics 1-9
- Recorded Data and Application of Regional Regression Equations 1-13
- Comparison With Similar Watersheds 1-22
- Flood Estimate from Precipitation 1-27
- Storm Distribution 1-28

Special Consideration - Initial Reservoir Storage 2-35

Other Studies - Past and Present 1-41

Discussion of Results 1-49

Conclusions and Recommendations 1-50

TABLES

1 Records of Rainfall - Guadalupe River Basin 1-8

2 Annual Peak Discharges - Guadalupe River Hydrology, August 1977 1-14

3 Summary of Statistical Analysis, Guadalupe River Hydrology, August 1979 1-15

4 Upper Guadalupe 1% Flood, Rainfall Generated Flows, Coincident Frequency Reservoir Level 1-29

5 Comparison of 1976 Regional Equations Balanced Hydrographs and Rainfall Generated Hydrographs ... 1-30

6 Comparison of 24-Hour and 72-Hour Storm Distribution 1-31

7 Comparison of Northern California and Southern California Storm Distributions 1-34

8 Upper Guadalupe 1% Flood, 1976 SCVWD Regional Equations, Coincident Frequency Reservoir Level .. 1-43

9 Lower Guadalupe 1% Flood, 1976 SCVWD Regional Equations, Coincident Frequency Reservoir Level .. 1-44

10 Annual Maximum 24-Hour Volume (average cfs), Guadalupe River Hydrology, August 1977 1-46

11 1% 24-Hour Flood Volumes, Guadalupe River Hydrology, August 1977 1-47

TABLES (continued) Page

12 1% Flood (cfs) Comparison of Results, August 1977 1-48

13 Guadalupe River Recommended 1% Flood Flows, August 1977 1-52

14 Guadalupe River Recommended 10% Flood Flows, August 1977 1-55

FIGURES

1 Peak Flow-Frequency, Alamitos Creek Upstream of Guadalupe Creek, USGS #167000, 1930-1957 1-16

2 Peak Flow-Frequency, Guadalupe Creek at Los Gatos Golf Course, SCVWD #43, 1930-1976 1-17

3 Peak Flow-Frequency, Golf Creek near McAbee Road, SCVWD #18, 1946-1976 1-18

4 Peak Flow-Frequency, Ross Creek below Jarvis Road, SCVWD #51, 1957-1976 1-19

5 Peak Flow-Frequency, Los Gatos Creek at Los Gatos, SCVWD #67, 1930-1944 1-20

6 Peak Flow-Frequency, Guadalupe River at San Jose, USGS #169000, 1930-1951 1-21

7 Adjusted Peak Flow-Frequency, Guadalupe River at San Jose, USGS #169000, 1930-1951 1-25

8 Adjusted Peak Flow-Frequency, Los Gatos Creek at Los Gatos, SCVWD #67, 1930-1944 1-26

9 Calero Reservoir Storage - Duration Curve 1-36

10 Almaden Reservoir Storage - Duration Curve 1-37

11 Guadalupe Reservoir Storage - Duration Curve 1-38

PLATES

1 Upper Guadalupe River Drainage Area................ 1-4

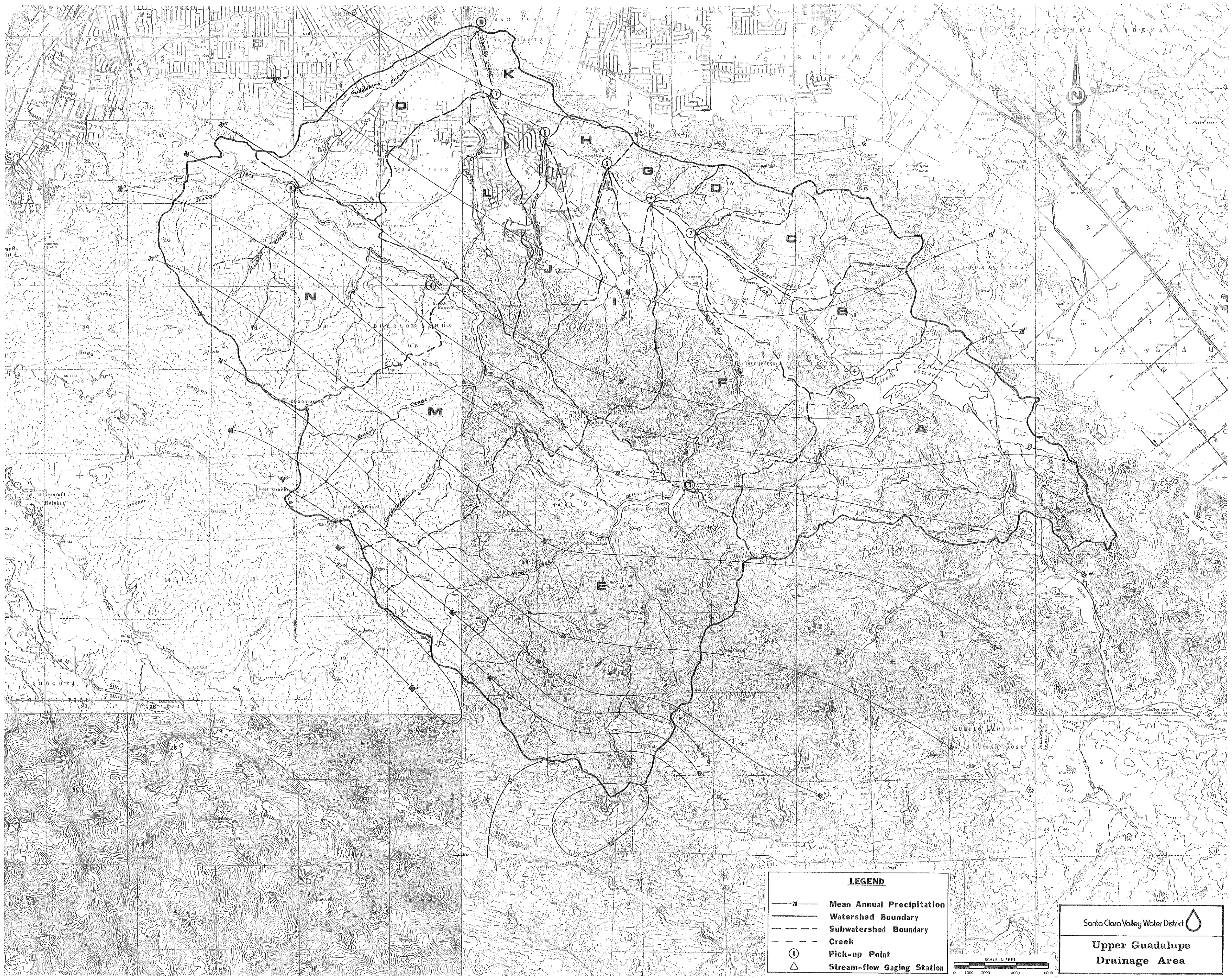
2 Lower Guadalupe River Drainage Area................ 1-5

GENERAL INFORMATION

The upper watershed of Guadalupe river is drained by three major tributaries; Alamitos, Guadalupe and Los Gatos Creeks.

The Guadalupe River begins at the confluence of Guadalupe Creek and Alamitos Creek. The river system drains an area of over 170 square miles before emptying into San Francisco Bay. Most of the watershed (plates 1-1 and 1-2) lie in the high rainfall area of the Santa Cruz Mountains. The basin receives an average annual rainfall ranging from 14 inches on the valley floor to over 50 inches on the 3800 foot Loma Prieta Peak.

There are three reservoirs on the upper Guadalupe and Alamitos Creeks (Calero, Almaden and Guadalupe) constructed by the Santa Clara Valley Water Conservation District (SCVWCD) in 1935 which have combined capacity of 15,680 acre-feet. Of the three principal reservoirs existing on Los Gatos Creek, the first and smallest is Vasona Reservoir (400 AF), built in 1935 by the SCVWCD. The second is Austrian Dam, constructed in 1950 by San Jose Water Works in the upper reaches of the Los Gatos Creek drainage, where it impounds the 6,150 acre-foot Lake Elsman. The largest dam is Lexington, which was completed by the SCVWCD in 1952 and has a capacity of 20,250 acre-feet. All the reservoirs were constructed for conservation purposes. However, flood control benefits are accrued incidentally.



Santa Clara Valley Water District

Upper Guadalupe Drainage Area

Plate 1-1

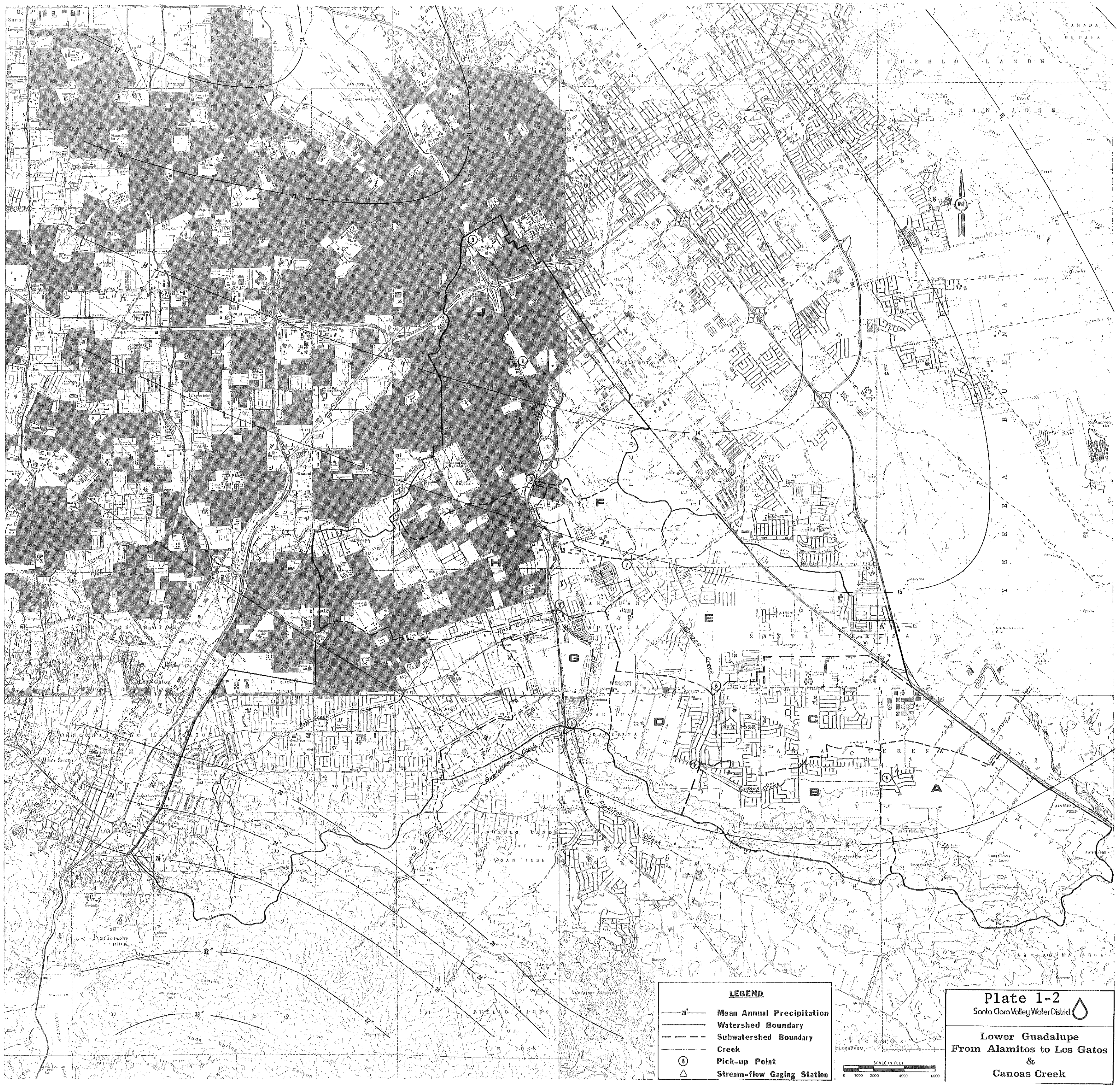


Plate 1-2
Santa Clara Valley Water District

Lower Guadalupe
From Alamitos to Los Gatos
&
Canoas Creek

Historic Events

Flooding from the Guadalupe River has been plaguing the City of San Jose since it was founded in 1777, as chronicled in History of San Jose, by James and McMurry:

> "Floods twice crumbled the mud walls of the rough homes in January and February, 1779."

The records of Mission Santa Clara, show that two years after its founding, the Mission had to be moved from its original location on the bank of Guadalupe River to higher ground, because of the flood damage that it had sustained. According to James and McMurry, some of the most noteworthy flooding in early days occurred during the 1860's.

> "The Los Gatos and Guadalupe Creeks overflowed in severe floods of March 1862 and December 20, 1867 --- in the latter the Los Gatos Creek cut out its present course ..." "The severest flood of American times (February 8, 1869) ... backed the waters four feet deep south of Santa Clara Street. Water also covered an area from Third to Seventh Streets."

> "... a flood (December 18-20, 1871) when a 48-hour 17-inch rain inundated the western portion of the City, swept seven River Street cottages 600 yards downstream and suspended rail and telegraph communications for two days."

There have been dramatic floods in more recent years and since 1930 these high flow rates have been recorded by the U.S. Geological Survey at a stream gage located just below the confluence with Los Gatos Creek (D.A. = 150 square miles).

Highest Instantaneous peak flows 1930-1974 (in order of magnitude) follows:

1.	9150 cfs	April 2, 1958
2.	8680 cfs	February 27, 1940
3.	8000 cfs	January 12, 1952
4.	6760 cfs	March 16, 1967
5.	6700 cfs	December 27, 1931
10.	6300 cfs	October 13, 1962
12.	5570 cfs	December 23, 1955

The San Jose Mercury Herald provides a good account of the effects of some of these larger flows:

February 27, 1940

> "... submerged often dampened Alviso with one of the worst floods in its history."
>
> "... flood problem ... when storm swollen Guadalupe Creek burst its banks in lowland area north of San Jose."

Flows in streams are affected by the combination of prior rainfall, soil condition and available storage capacity. Under proper conditions, a storm of a certain intensity may cause a flow of larger size than what is expected. This is obvious as the dates of the maximum recorded 1-day* rainfalls, complied in Table 1-1 for several precipitation stations in the Guadalupe Basin, do not necessarily fall on the same days as the larger flows.

*One-day rainfall was used as it was readily available. The maximum 24-hour rainfall would be approximately 13% higher.

TABLE 1-1

Records of Rainfall
Guadalupe River Basin

	Max. Annual Recorded 1-Day Rainfall		
#86 San Jose	1	4.32	Sept. 12, 1918
Elev - 95	2	3.77	Jan. 30, 1968
1907-1973	3	3.21	Oct. 13, 1962
#12 Calero Reservoir	1	7.70	Jan. 31, 1963
Elev - 500	2	4.31	Jan. 19, 1969
1958-1975	3	3.82	Feb. 25, 1958
#32 Guadalupe Reservoir	1	7.62	Jan. 31, 1963
Elev - 540	2	6.67	Jan. 12, 1952
1936-1975	3	5.51	Dec. 23, 1955
#2 Alma College	1	8.10	Dec. 23, 1955
Elev - 900	2	8.08	Jan. 21, 1943
1916-1973	3	7.93	Jan. 31, 1963
#55 Millberry	1	10.25	Jan. 31, 1963
Elev - 1800	2	9.57	Dec. 23, 1955
1941-1972	3	7.45	Jan. 19, 1969

Discussion of Procedures

Basin Characteristics

The Guadalupe River Basin is divided into two major watersheds, Upper Guadalupe which includes rural subareas A through O and Lower Guadalupe which includes urban subareas G through M (plates 1-1 and 1-2). A partial list of the rural subareas has the following basin characteristics.

Location	Sub-area	Drainage Area (sq. mi.)	Mean Annual Precipitation (in.)	L/s $(mi^2/ft/ft)^{1/2}$	Tc (hours)
Calero Reservoir Inflow	A	6.99	24.5	187	2.09
Arroyo Calero Creek u/s Santa Teresa Creek	B	2.65	18.0	78	1.25
Santa Teresa Creek u/s Calero Creek	C	1.99	17.0	42	.91
Almaden Reservoir Inflow	E	12.00	37.5	38.7	.69
Alamitos Creek u/s Calero Creek	F	4.24	21.0	137	1.67
Randol Creek u/s Alamitos Creek	I	2.28	19.0	31	.70
Greystone Creek u/s Alamitos Creek	J	1.38	18.0	26	.70
Golf Creek u/s Alamitos Creek	L	3.08	18.0	44	1.07
Guadalupe Reservoir Inflow	M	5.96	31.0	28	.68
Guadalupe Creek u/s Alamitos Creek	O	2.53	18.0	89	1.73

The following urban areas are treated based on the District's method with a ratio of imperviousness representing medium residential density.

Location	Subarea	*Drainage Area (sq. mi.)	Mean Annual Precipitation (in.)	Tc (hours)
Guadalupe River Upstream Ross Creek	G	AI-1.00 AP-1.09	15.5	1.5 3.5
Guadalupe River Upstream Canoas Creek	H	AI-2.84 AP-1.89	15.5	1.75 3.75
Guadalupe River at West Alma Street	I	AI-2.42 AP-1.04	14.5	1.40 3.40
Guadalupe River Upstream Los Gatos Creek	J	AI-2.59 AP- .65	13.5	1.70 3.70
Guadalupe River at Highway 17	K	AI-2.80 AP-1.19	13.0	1.60 3.60
Guadalupe River at Highway 101	L	AI-4.30 AP-1.83	12.5	2.10 4.10
Guadalupe River at Highway 237	M	AI-5.00 AP-5.39	12.0	2.70 4.70

*AI = impervious urban area
AP - pervious urban area

In rural areas, the preliminary evaluation of design flows from regional regression equations is determined using the drainage areas, mean annual precipitation and basin factors. These preliminary values are compared with peak flows obtained from rainfall by employing the unit hydrograph theory and HEC-1 program. Although this latter technique is used mainly to define design hydrographs, the resultant peak flow is compared and balanced against the regional one. As will be shown later, the end result of the above procedure is further compared with results from the site specific analysis of recorded data if available.

Urban areas are treated based on the District's method of urban hydrology (Reference 3). The density of land use is dertmined by the ratio of impervious to pervious parts.

The data from the remaining six stream gages are biased by upstream water regulations and urbanization. The data are continuous and long. For all of these reasons the data were analyzed and statistics obtained but caution was exercised when using the results.

The following are the names of the stations and the results of the statistical analysis.

USGS #167000	Alamitos Creek Upstream of Guadalupe Creek
USGS (SCVWD #43)	Guadalupe Creek at Los Gatos Golf Course
SCVWD #18	Golf Creek near McAbee Road
SCVWD #51	Ross Creek below Jarvis Road
USGS (SCVWD #67)	Los Gatos Creek at Los Gatos
USGS #169000	Guadalupe River at San Jose

The Alamitos Creek gage (USGS #16700) was established by the USGS in 1930 and has continuous records through 1957 when it was discontinued. Analysis of these records yielded a 1% flow rate = 7,900 cfs. This record is affected by both Almaden and Calero Reservoirs which have controlled over half (54%) the drainage area of the gage since 1935. (Figure 1-1, page 1-16)

The Guadalupe Creek at Los Gatos Golf Course gage (now SCVWD #43) has continuous records since 1930. The records since 1935 at this gage have been affected by Guadalupe Reservoir which controls about half (43%) of the drainage area at the gage. Statistical analysis of these records yielded a 1% flow rate - 2,811 cfs. (Figure 1-2, page 1-17)

The Golf Creek gage (SCVWD #18) near McAbee Road is the only stramflow gage in the Alamitos Creek watershed with unregulated data. The gage has fair records since 1946. Statistical analysis of these records yielded a 1% flow rate - 620 cfs. (Figure 1-3 page 1-18)

The Ross Creek gage (SCVWD #51) below Jarvis Road measures flow from the entire Ross Creek watershed and has fair records since 1957. Using the Log Pearson Type III distribution with the regional skew coefficient (-.6) the 1% flow rate = 2304 cfs (Figure 1-4, page 1-19). This gaging station measures a great deal of urban as well as rural drainage. Therefore, the applicability of the Log Pearson Type III frequency distribution may not be entirely correct. For further details on Ross Creek see Reference 3.

The former USGS stream gage (now SCVWD #67) located just below Lexington Dam has a total of 44 years of record, with the first fifteen reflecting a natural watershed (prior to 1944 when the gage was moved downstream). This station was used in all SCVWD regional frequency regression studies. Statistical analysis of the 15 years of unregulated flow produced 1% flow rate = 12,301 cfs. (Figure 1-5, page 1-20)

The USGS has operated a stream gage (USGS 169000) on the Guadalupe River just below the confluence with Los Gatos Creek since 1930. Statistical analysis of the entire 45 years of record yields 15,422 cfs as the 1% flow value. With only the records from 1930 to 1951, prior to the construction of Lexington Reservoir, the statistical analysis yielded a 1% flow rate = 16,312 cfs. (Figure 1-6, page 1-21.) The streamflow records have been affected by all the reservoirs upstream (Calero, Almaden, Guadalupe, Lake Elsman, Lexington, and Vasona). The 1% flow estimates for a completely unregulated watershed would be expected to be higher.

The annual peak discharges for the above gaging stations are listed in Table 1-2. The summary of the statistical analysis is tabulated in Table 1-3. The frequency curves are plotted in Figures 1-1 through 1-6.

Recorded Data and Application of Regional Regression Equations

Inherent in the District's hydrology methods are checking procedures that utilize data wherever available. Systematic records, historic data, stochastic data, and data obtained from rainfall are utilized. Following is a discussion of all of these procedures and their application to Guadalupe River.

There are fourteen stream flow gaging stations in the Guadalupe River Basin. Because of either upstream regulation, urbanization, or unreliable data, statistical analysis of District stream gages 19, 59, 50, 20, 23, 13, 16, and 17 revealed inconclusive results and therefore, they were omitted from this analysis. Station 20 below the confluence of Alamitos and Guadalupe would have been of particular interest but important data were missing.

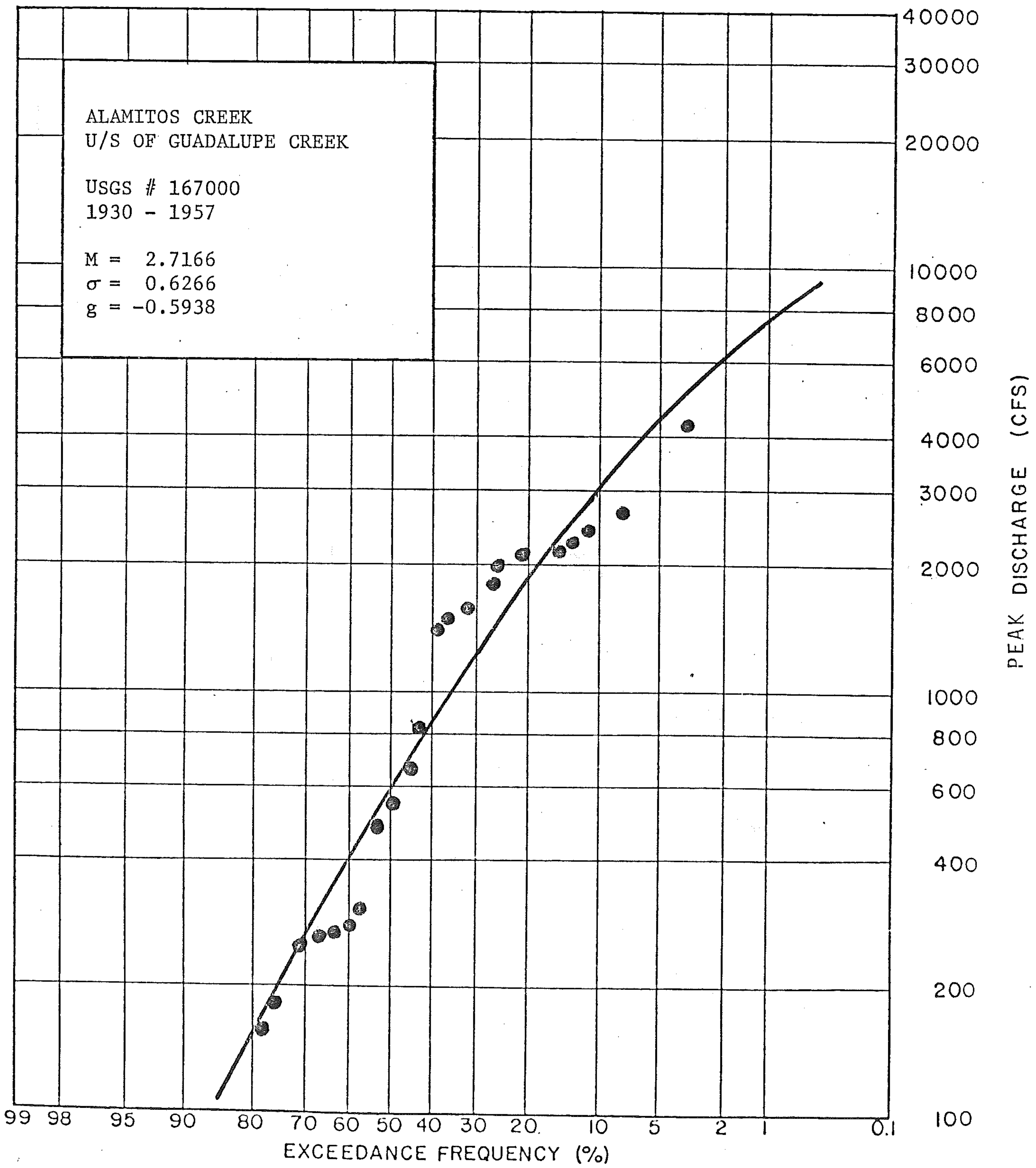
TABLE 1-2

ANNUAL PEAK DISCHARGES
GUADALUPE RIVER HYDROLOGY
AUGUST 1977

Water Year	Alamitos Creek U/S Guadalupe Creek USGS #1670	Guadalupe Creek @ Los Gatos Golf Course SCVWD #43	Golf Creek Near McAbee Rd. SCVWD #18	Ross Creek Below Jarvis Rd. SCVWD #51	Los Gatos Creek Below Lexington Dam SCVWD #67	Guadalupe River @ San Jose USGS #1690
1929						
1930	1,770	962				
1931	NR	50			2,160	4,330
1932	2,670	1,160			221	NR
1933	175	234			3,340	6,700
1934	1,490	525			582	365
1935	582	370			1,080	2,450
1936	270	182			1,040	1,650
1937	1,840	520			1,310	910
1938	2,280	1,150			5,500	6,070
1939	47	84			4,800	6,600
1940	2,440	705			485	338
1941	2,520	988			7,110	8,680
1942	815	310			4,150	6,330
1943	2,390	722			2,700	4,090
1944	314	152			4,610	6,350
1945		850			1,270	1,960
1946	500	181	112			6,660
1947	36	52	29			1,640
1948	45	205	83			394
1949	269	238	120			890
1950	83	102	NR			2,500
1951	650	202	50			1,340
1952	2,000	1,330	205			2,730
1953	268	161	130			8,000
1954	98	161	70			738
1955	136	230	98		175	485
1956	4,140	1,320	380		81	608
1957	262	216	200	115	1,460	5,570
1958		2,750	500	480	73	666
1959		571	270	NR	3,540	9,150
1960		NR	12	45	311	1,590
1961		30	15	230	103	125
1962		470	230	583	92	279
1963		2,000	350	880	181	1,380
1964		360	140	820	1,660	6,300
1965		220	48	850	198	1,980
1966		120	190	320	153	1,340
1967		1,700	NR	1,030	96	1,380
1968		1,000	NR	1,550	3,530	6,760
1969		800	215	845	204	5,170
1970		250	56	550	1,450	3,840
1971		395	180	952	318	2,010
1972		71	43	285	82	3,260
1973		581	260	581	158	1,490
1974		335	125	617	746	4,380
1975		158	75	465	163	3,220
1976		22	41	248	189	2,320
Drainage Area (Sq. mi.)	34.6	12.7	2.26	7.6	38.6	144.0

TABLE 1-3
SUMMARY OF STATISTICAL ANALYSIS
GUADALUPE RIVER HYDROLOGY
AUGUST 1977

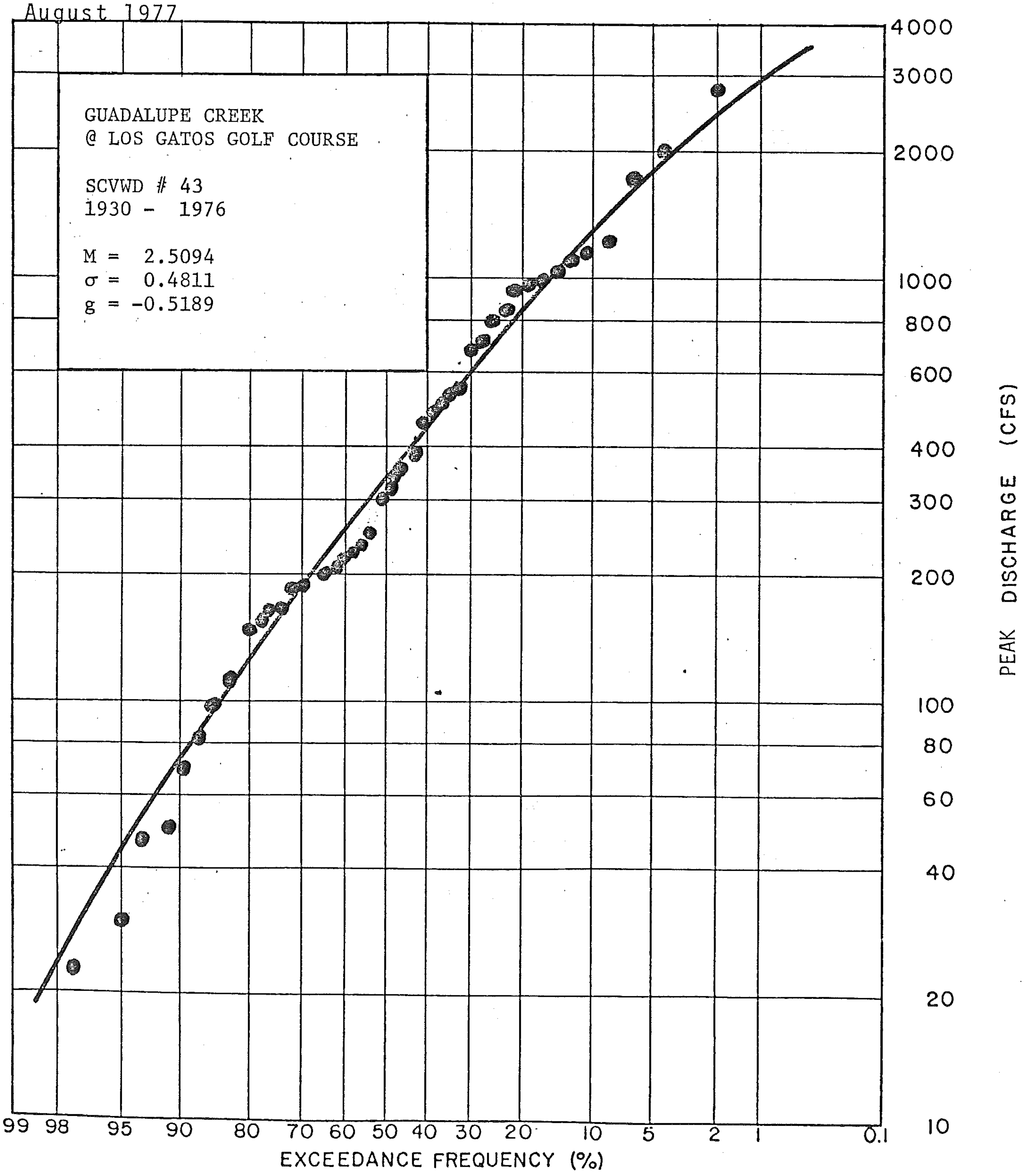
Station	Year of Record	Drainage Area (Sq. Mi.)	Mean	Standard Deviation	Weighted Skew Coefficient	$Q_{1\%}$	$Q_{10\%}$	1% Flow C.S.M.
Alamitos Creek Near Edenvale USGS #1670	1930-1957	34.6	2.7166	0.6266	-0.5938	7900	2950	228
Guadalupe Creek @ Los Gatos Golf Course SCVWD #43	1930-1976	12.7	2.5094	0.4811	-0.5189	2810	1250	221
Golf Creek Near McAbee Road SCVWD #18	1946-1976	2.2	2.0257	0.4077	-0.5994	620	330	282
Ross Creek Below Jarvis Road SCVWD #51	1957-1976	7.6	2.6703	0.3681	-0.6000	2300	1290	303
Los Gatos Creek Below Lexington Dam SCVWD #67	1930-1944	38.6	3.2608	0.4410	-0.6000	12300	6170	319
Guadalupe River @ San Jose USGS #1690	1930-1951	144.0	3.3675	0.4494	-0.6000	16310	8070	113
Guadalupe River @ San Jose USGS #1690	1930-1975	144.0	3.3193	0.4635	-0.6076	15420	7500	107



Data regulated by Almaden, Calero Reservoirs

FIGURE 1-1

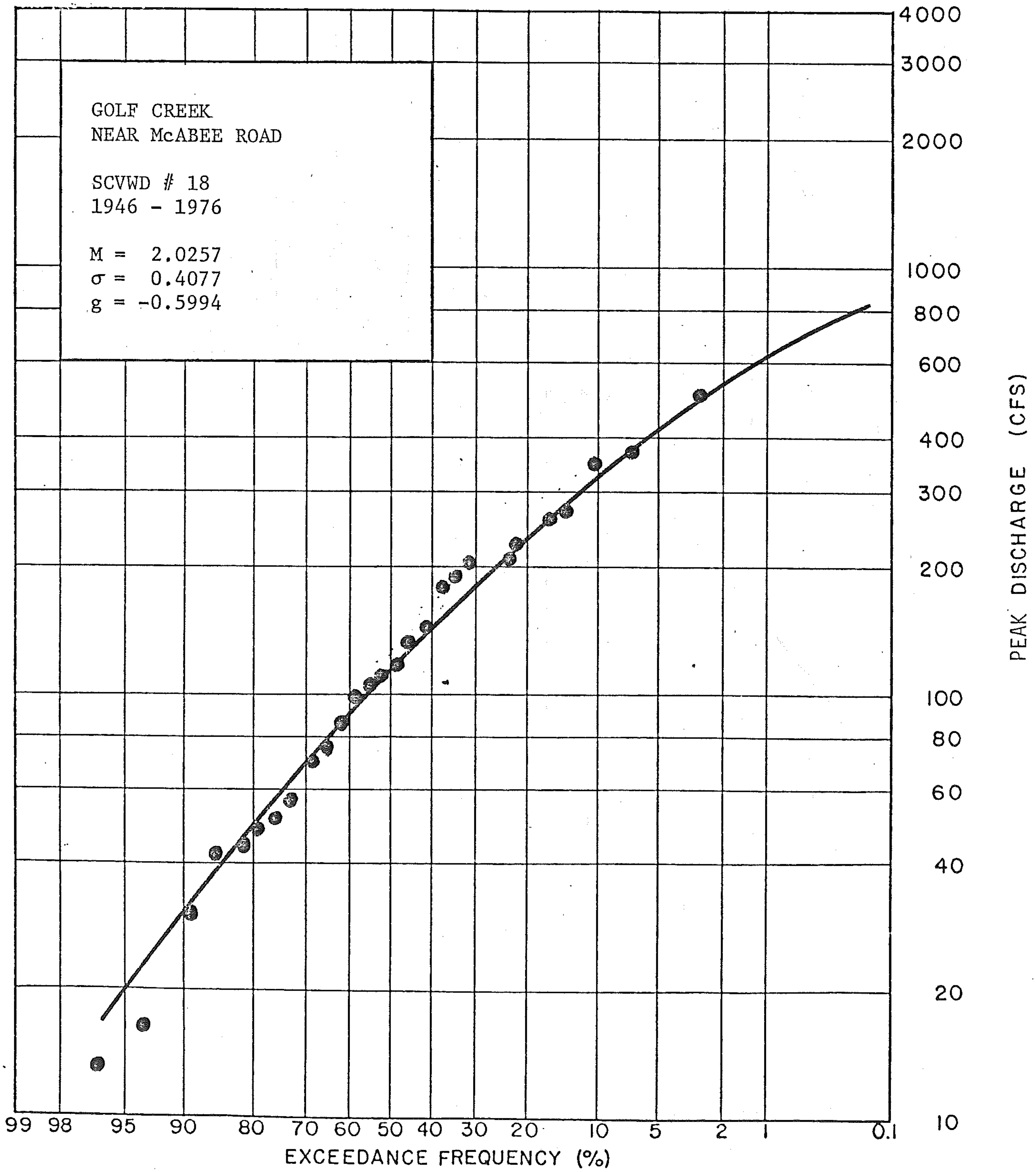
August 1977



Data regulated by Guadalupe Reservoir

FIGURE 1-2

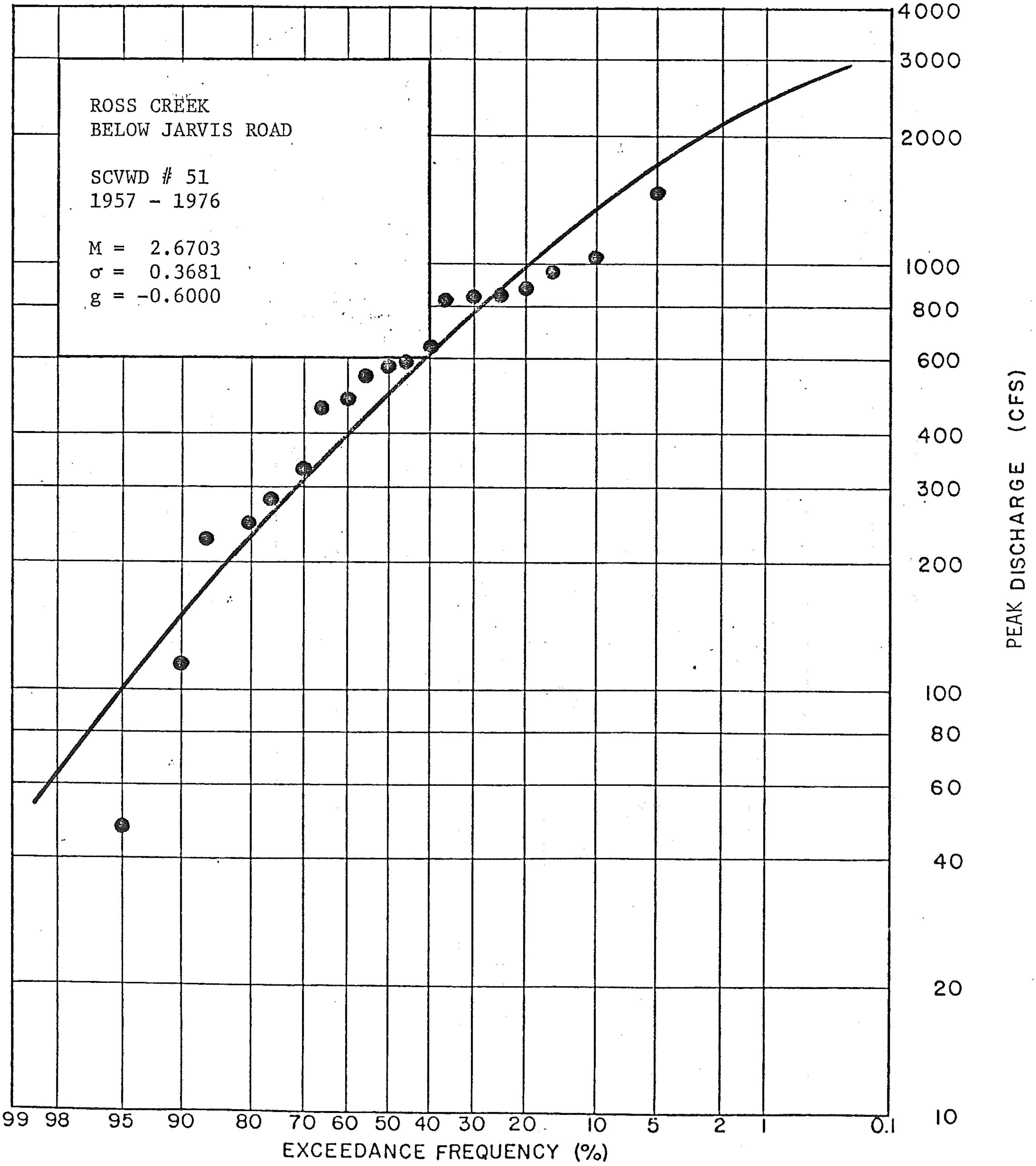
August 1977



Data influenced by urbanization

FIGURE 1-3

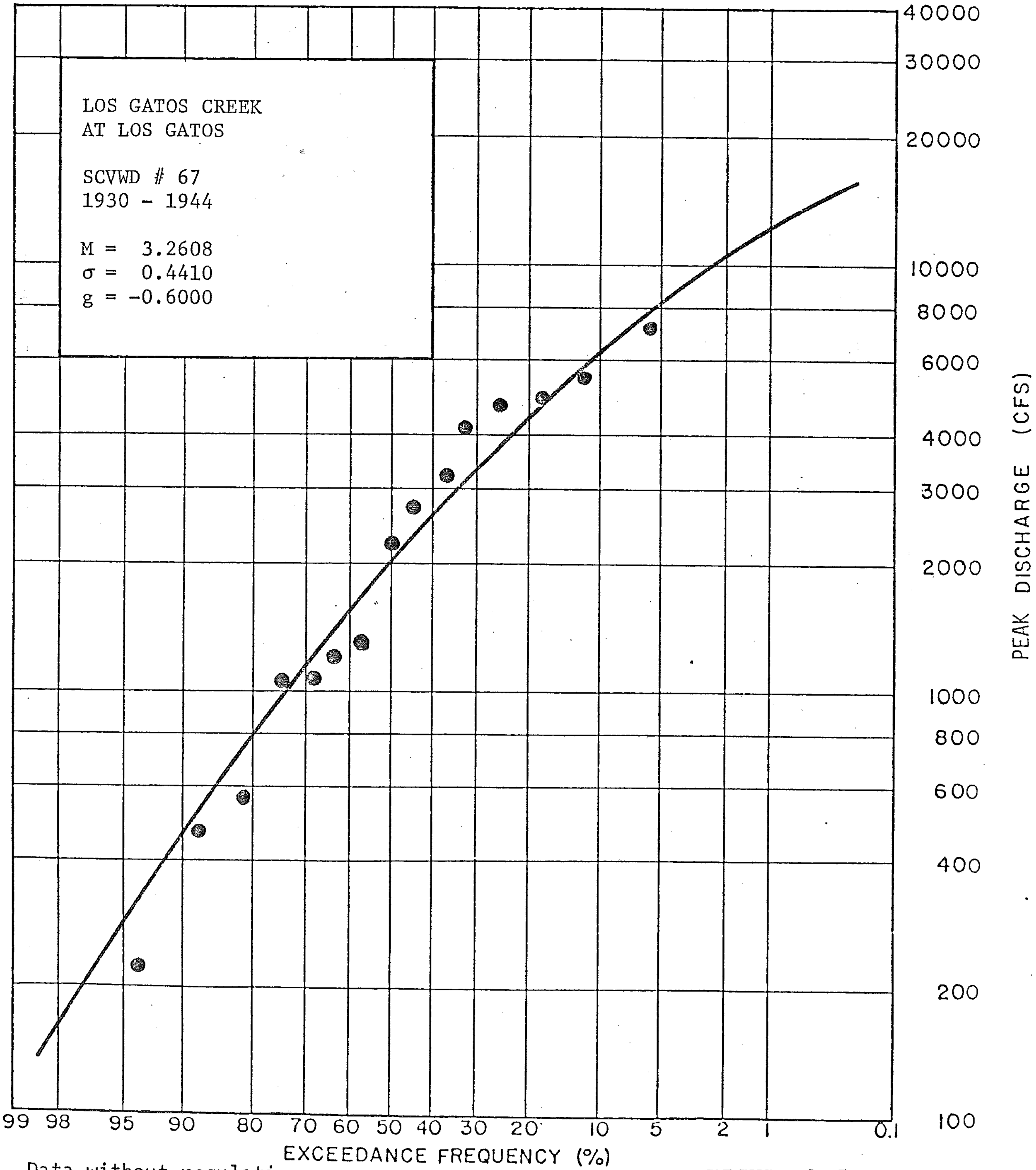
August 1977



Data influenced by urbanization

FIGURE 1-4

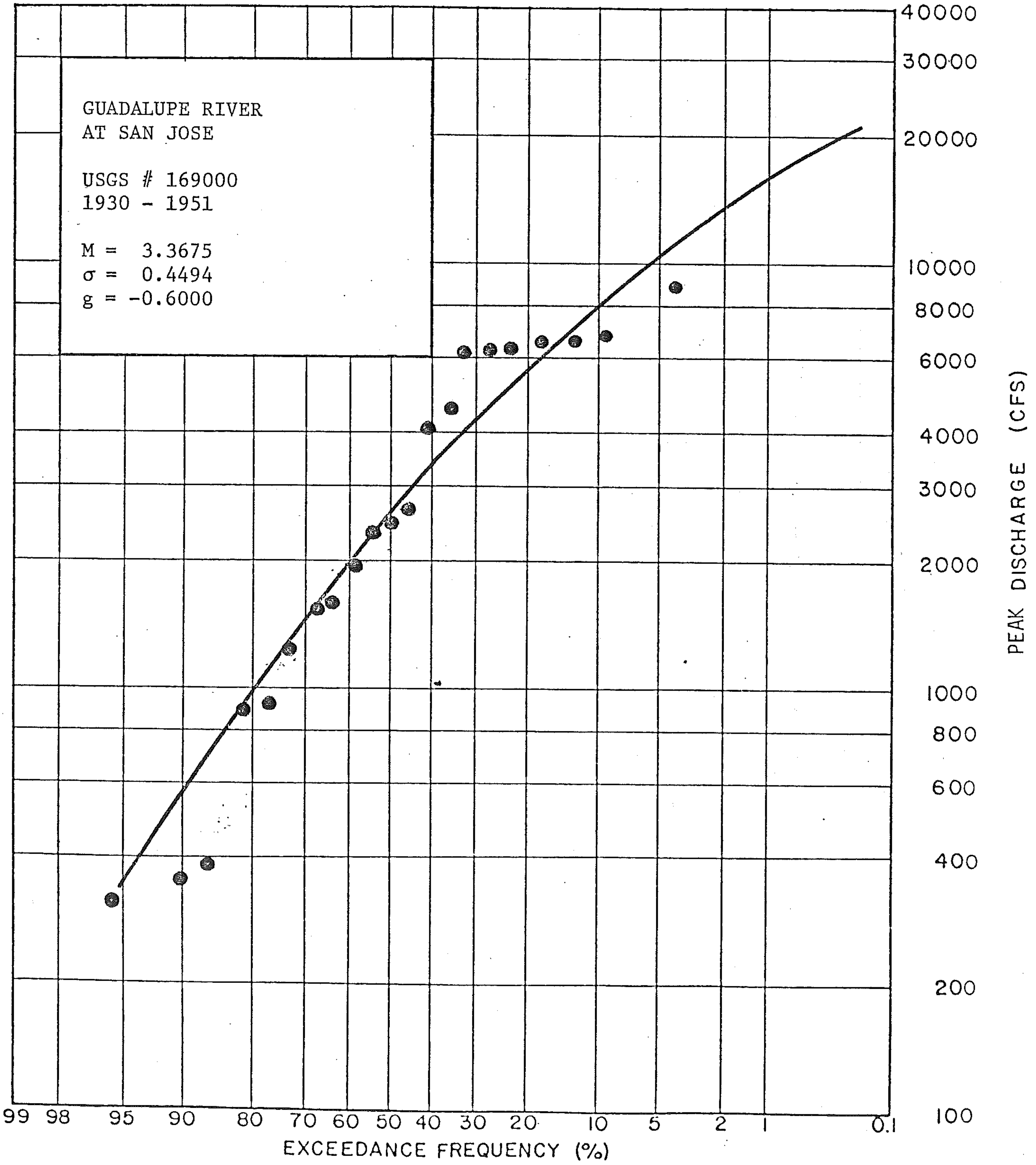
August 1977



Data without regulation

FIGURE 1-5

August 1977



Data regulated by all reservoirs except Lexington

FIGURE 1-6

Comparisons with Similar Watersheds

Comparisons between frequency curves and maximum flood data of the watershed being investigated and those in a hydrologically similar region are useful for identification of unusual events and testing the reasonableness of flow-frequency determinations.

The Arroyo Seco near Soledad gage has a long, continuous and reliable record which goes back as far as 1906. Using the 21 years of record (1930-1951) at the Guadalupe River Station at San Jose (U.S.G.S. No. 1690), the correlation coefficient (r) between the two stations was 0.73 (fair). Based on this correlation and the regional skew coefficient of -0.60, adjusted statistics resulted in a 1% flow rate = 15,825 cfs. Additional correlation was done with the Saratoga Creek gage at Saratoga (4=0.90) to supplement the results obtained from Arroyo Seco gage. Using the regional skew coefficient of -0.60, the 1% flow rate = 16,022 cfs.

Although the data after Lexington Reservoir was built (1952) were excluded from the data base, the remaining data are still biased by reservoirs upstream. However, since the effect of those reservoirs is dampened at locations downstream, the results are considered acceptable.

On Los Gatos Creek the 15 years of natural, unregulated streamflow records of at the gage below Lexington Dam were correlated with the USGS Station at Saratoga, which is in the watershed immediately to the northwest. The USGS Station at Saratoga has continuous records since 1934. Analysis gave an equivalent 30 years of record with a correlation coefficient of 0.92; the 1% flow rate = 10,213 cfs. Additional correlation was done with Arroyo Seco gage to supplement the results obtained from Saratoga gage. This analysis gave an equivalent years of record at Los Gatos gage of over 38 years with a correlation coefficient of 0.88, the 1% flow rate = 11,900 cfs. The same 15 years of record were correlated in a matrix with data from 20 other streamflow stations having up to 60 years of record (see Reference 4). This correlation gave an equivalent years of record of 55 years; the 1% flow rate = 11,467 cfs.

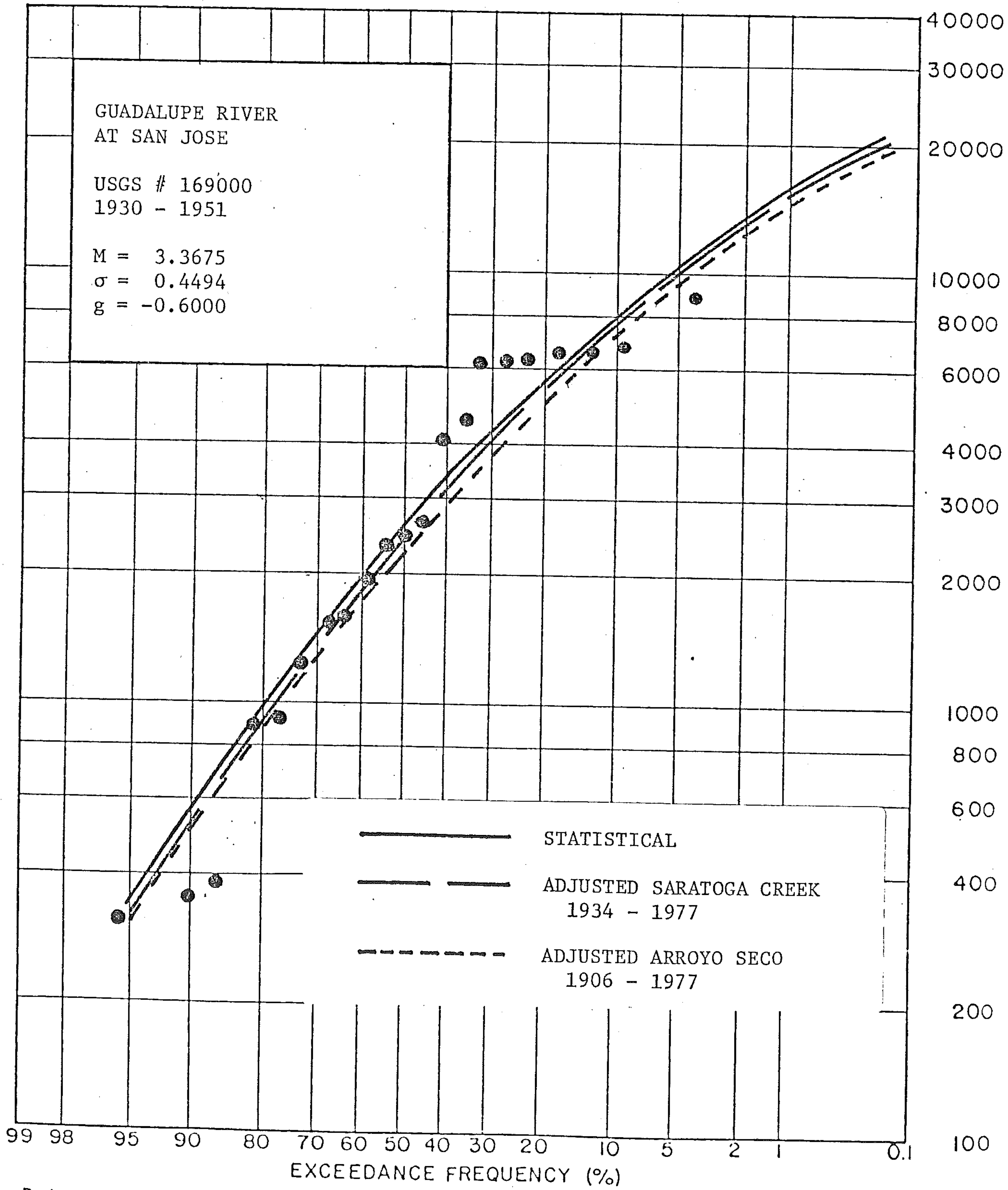
There was some concern over the accuracy of the records kept by the USGS at the Saratoga Creek gage and Los Gatos Creek gage. During a phone conversation on January 31, 1975, Mr. Joe Robles of USGS indicated that he had no reason to question any of the records even when asked specifically about high flows. With the high statistical correlation and this confidence, the results were considered good.

Results are summarized as follows:

	Statistical Analysis	Adjusted Statistics with Arroyo Seco 1906-1977	Adjusted Statistics with Saratoga Creek 1934-1977
Skew Coefficient, g	-0.6000	-0.6000	-0.6000
Guadalupe River at San Jose USGS #169000 1930-1951	$M = 3.3675$ $\sigma = 0.4494$ $Q_{1\%} = 16,312$ cfs	$M = 3.3079$ $\sigma = 0.4741$ $R = 0.7297$ $Q_{1\%} = 15,825$ cfs $N_e = 32.80$ years	$M = 3.3441$ $\sigma = 0.4577$ $R = 0.9002$ $Q_{1\%} = 16,022$ cfs $N_e = 34.08$ years
Los Gatos Creek below Lexington Dam, SCVWD #67 1930-1944	$M = 3.2608$ $\sigma = 0.4410$ $Q_{1\%} = 12,301$ cfs	$M = 3.2296$ $\sigma = 0.4499$ $R = 0.8849$ $Q_{1\%} = 11,900$ cfs $N_e = 38.13$ years	$M = 3.2608$ $\sigma = 0.3980$ $R = 0.9236$ $Q_{1\%} = 10,213$ cfs $N_e = 29.54$ years

The frequency curves of this summary are plotted in Figures 1-7 and 1-8.

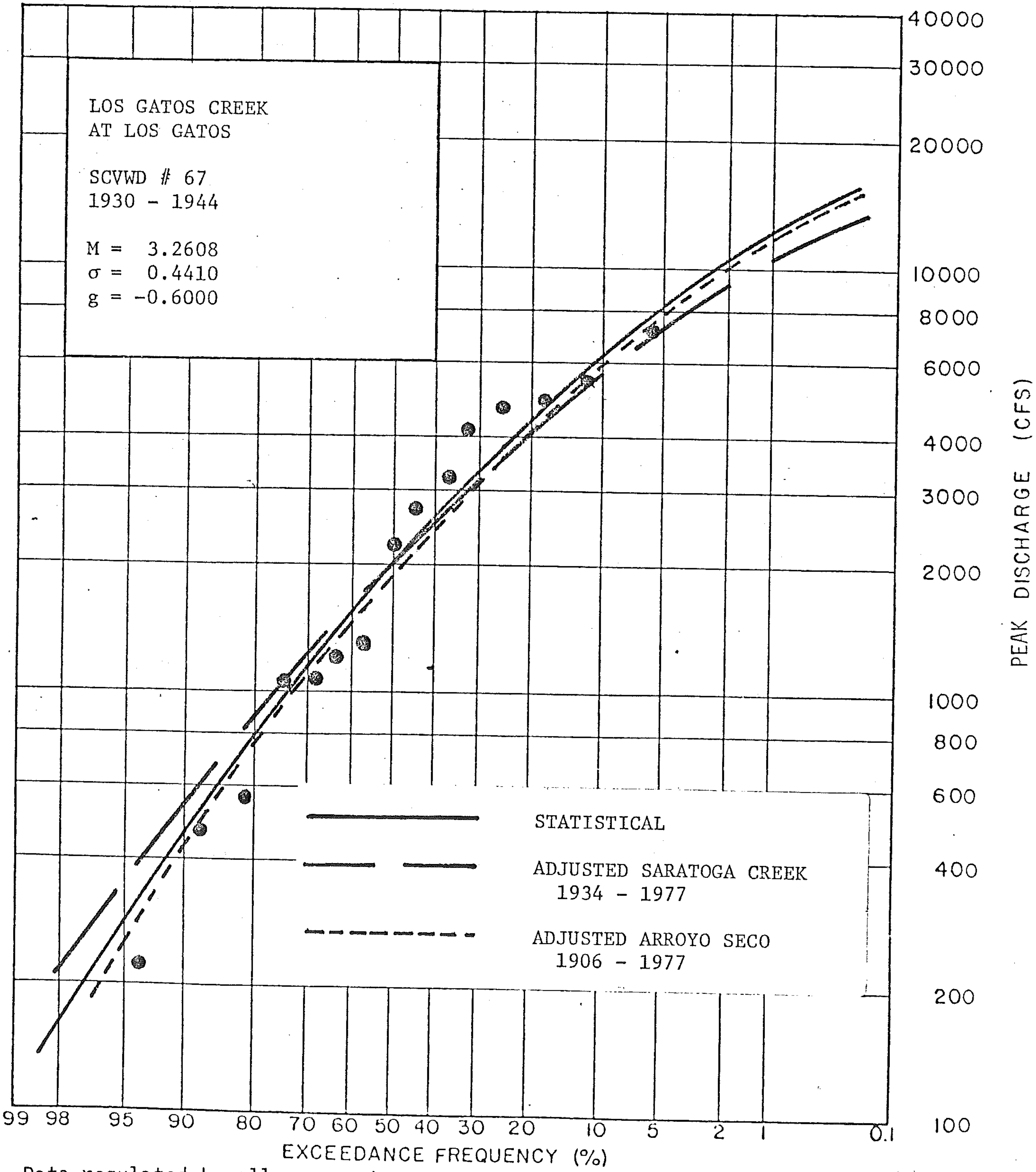
August 1977



Data regulated by all reservoirs except Lexington

FIGURE 1-7

August 1977



Data regulated by all reservoirs except Lexington

FIGURE 1-8

Flood Estimates from Precipitation

In Santa Clara County, the mean annual precipitation (M.A.P.) reflects well the integrated effects of availability of atmospheric moisture, of elevation and topography, and of efficiency of the orographic mechanism, which are significant parameters of storm rainfall. It was therefore possible to develop a relationship of storm magnitude vs. M.A.P. for different durations and frequency using data collected from rainfall stations in and around the county. The 24-hour rain with an exceedance frequency of 1% is used as the design storm. Values for the design storm at each of the precipitation stations in Table 1-1 are as follows:

#86 San Jose	5.43 inches
#12 Calero Reservoir	8.00 inches
#32 Guadalupe Reservoir	9.32 inches
# 2 Alma College	11.19 inches
#55 Millberry	12.73 inches

If these values are compared with the historic values in Table 1-1, it is evident that some of these values have already been exceeded.

The unit hydrograph theory was employed to convert the rainfall to runoff. Clark's synthetic unit hydrograph was used with the Corps of Engineer's 24-hour Northern California standard storm distribution and a 30% loss rate to generate flood hydrographs. The results of this approach for the Upper Guadalupe watershed are compiled in the flow summary Table 1-4. These are rough figures and a loss rate parameters optimization technique could help refine them further; however, they do provide a guide to relative orders of magnitude.

Table 1-5 compares the results of the 1% flood based on the 1976 Regional Regression Equations with the rainfall generated hydrographs.

Storm Distribution

It has been a standard procedure to use the 24-hour rain and the standard project storm distribution for Northern California Coastal Streams developed by the Corps of Engineers in hydrologic studies in the District. This is the main contrast to the 72-hour storm used by the Corps of Engineers in their hydrology reports for Guadalupe River. There has been some concern about which storm duration will give a more critical design flood. To test the sensitivity of 24-hour storm duration in this study, comparisons were made on the Upper Guadalupe Watershed between using the 24-hour storm, balanced with peak and 24-hour volume, and the 72-hour storm, balanced with peak, 24-hour, 48-hour, and 72-hour volumes. Peaks and volumes were all based on 1976 Regional Regression Equations. Results of the storm analysis are tabulated in Table 1-6.

TABLE 1-4

UPPER GUADALUPE 1% FLOOD
RAINFALL GENERATED FLOWS
COINCIDENT FREQUENCY RESERVOIR LEVEL

RUNOFF SUMMARY, AVERAGE FLOW

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA	
HYDROGRAPH AT	1	2213	1739	1020	503	6.99	INFLOW TO CALERO RESERVOIR
ROUTED TO	1	691	663	461	317	6.99	OUTFLOW FROM CALERO RESERVOIR
ROUTED TO	2	683	657	460	315	6.99	
HYDROGRAPH AT	2	845	570	321	156	2.65	ARROYO CALERO CREEK
2 COMBINED	2	1030	888	669	471	9.64	
HYDROGRAPH AT	2	657	418	233	113	1.99	SANTA TERESA CREEK
2 COMBINED	2	1687	1252	872	584	11.63	
ROUTED TO	4	1679	1252	872	583	11.63	
HYDROGRAPH AT	4	293	163	89	43	.76	
2 COMBINED	4	1923	1399	954	626	12.39	
HYDROGRAPH AT	3	4107	3482	2199	1137	12.00	INFLOW TO ALMADEN RESERVOIR
ROUTED TO	3	3917	3461	1751	961	12.00	OUTFLOW FROM ALMADEN RESERVOIR
ROUTED TO	4	3797	3444	1751	958	12.00	
HYDROGRAPH AT	4	1329	979	565	276	4.24	
2 COMBINED	4	4929	4344	2220	1234	16.24	
2 COMBINED	4	6584	5728	3162	1860	28.63	
ROUTED TO	5	6576	5722	3162	1859	28.63	
HYDROGRAPH AT	5	269	154	85	41	.74	
2 COMBINED	5	6738	5852	3237	1901	29.37	
HYDROGRAPH AT	5	789	513	288	140	2.28	RANDOL CREEK
2 COMBINED	5	7370	6306	3500	2040	31.65	
ROUTED TO	6	7392	6308	3500	2039	31.65	
HYDROGRAPH AT	6	275	164	91	44	.77	
2 COMBINED	6	7572	6447	3584	2083	32.42	
HYDROGRAPH AT	6	506	306	170	82	1.38	GREYSTONE CREEK
2 COMBINED	6	7926	6708	3740	2166	33.80	
ROUTED TO	7	7971	6709	3738	2163	33.80	
HYDROGRAPH AT	7	997	675	386	188	3.08	GOLF CREEK
2 COMBINED	7	8872	7336	4104	2352	36.88	
HYDROGRAPH AT	7	199	130	80	39	.53	
2 COMBINED	7	9020	7455	4177	2391	37.41	
ROUTED TO	10	9068	7453	4176	2387	37.41	
HYDROGRAPH AT	10	182	115	66	32	.55	
2 COMBINED	10	9203	7553	4236	2419	37.96	
HYDROGRAPH AT	8	2205	1665	1010	499	5.96	INFLOW TO GUADALUPE RESERVOIR
ROUTED TO	8	1443	1264	565	391	5.96	OUTFLOW FROM GUADALUPE RESERVOIR
ROUTED TO	9	1435	1244	565	389	5.96	
HYDROGRAPH AT	9	2188	1734	1057	529	6.75	
2 COMBINED	9	3070	2714	1610	918	12.71	
ROUTED TO	10	2970	2674	1594	909	12.71	
HYDROGRAPH AT	10	826	571	327	159	2.53	
2 COMBINED	10	3379	3127	1903	1068	15.24	
2 COMBINED	10	12414	10631	6140	3486	53.20	CONFLUENCE OF GUADALUPE CREEK AND ALAMITOS CREEK

TABLE 1-5

GUADALUPE RIVER HYDROLOGY

Comparison of 1976 Regional Equations Balanced Hydrographs and Rainfall Generated Hydrographs

	Location	Drainage Area (Square Miles)	1976 Regional Equations	Rainfall Generated Flow
Upper Guadalupe Watershed	Inflow to Calero Reservoir	6.99	2594	2213
	Outflow from Calero Reservoir	6.99	633	691
	Inflow to Almaden Reservoir	12.00	4385	4107
	Outflow from Almaden Reservoir	12.00	3508	3917
	Alamitos Crk @ Greystone Lane	33.80	7804	7926
	Golf Crk U/S of Alamitos Creek	3.08	1171	997
	Alamitos Crk Below Golf Creek	36.88	8552	8872
	Alamitos Crk near New Almaden	37.96	8858	9203
	Inflow to Guadalupe Reservoir	5.96	2349	2205
	Outflow from Guadalupe Reservoir	5.96	921	1443
	Guadalupe Crk @ Los Gatos Golf Course	12.71	2781	3070
	Guadalupe Creek @ Alamitos Creek	15.24	2967	3379
	Guadalupe Creek @ Alamitos Perc Ponds	53.20	11778	12414

TABLE 1-6

GUADALUPE RIVER HYDROLOGY

COMPARISONS OF 24-HOUR AND 72-HOUR STORM DISTRIBUTIONS

	Location	Drainage Area (Square Miles)	24-Hrs. Storm, Bal. With Peak & 24-Hr Floods				* 72 Hrs. Storm Bal With Peak, 24,48,&72 Hr. Flds.			
			Full Reservoirs	Incidental Reservoirs Storages (SCVWD)	Corps of Engineers Reservoirs' Storages	With Calero Reservoir Full Condition (San Felipe)	Full Reservoirs	Incidental Reservoirs Storages (SCVWD)	Corps of Engineers Reservoirs Storages	With Calero Reservoir Full Condition (San Felipe)
UPPER GUADALUPE Watershed	Inflow to Calero Reservoir	6.99	2594	2594	2594	2594	2594	2594	2594	2594
	Outflow from Calero Reservoir	6.99	1151	633	455	1151	1019	558	389	1019
	Inflow to Almaden Reservoir	12.00	4385	4385	4385	4385	4417	4417	4417	4417
	Outflow from Almaden Reservoir	12.00	3557	3508	3537	3508	3471	3471	3471	3471
	Alamitos Crk @ Greystone Lane	33.80	8457	7804	7888	8280	8257	7867	7866	8254
	Golf Crk U/S of Alamitos Creek	3.08	1171	1171	1171	1171	1177	1177	1177	1177
	Alamitos Crk Below Golf Creek	36.58	9258	8552	8675	9032	9309	8921	8920	9310
	Alamitos Crk near New Almaden	37.96	9623	8858	9021	9361	9362	8962	8961	9362
	Inflow to Guadalupe Reservoir	5.96	2349	2349	2349	2349	2349	2349	2349	2349
	Outflow from Guadalupe Reservoir	5.96	1579	921	232	921	1574	236	229	236
	Guadalupe Crk @ Los Gatos Golf Course	12.71	3851	2781	2771	2781	3768	2776	2768	2776
	Guadalupe Creek @ Alamitos Creek	15.24	3991	2967	2954	2967	3813	3005	2994	3005
	Guadalupe Creek @ Alamitos Perc Ponds	53.20	13614	11778	11929	12281	13175	11966	11955	12366
LOWER GUADALUPE	Ross Creek @ Guadalupe River	9.96	1934	1934	1934	1934				
	Canoas Creek U/S of Guadalupe River	18.62	2196	2351	2196	2351				
	Guadalupe River Below Canoas Creek	88.60	18163	16508	16472	16994				
	Inflow to Lexington Reservoir	37.52	11145	11145	11068	11145				
	Los Gatos Creek Below Lexington	37.52	8933	6690	3637	6690				
	Los Gatos Creek @ Guadalupe River	54.83	11067	7976	4543	7976				
	Guadalupe River @ San Jose	150.13	27984	19804	19772	20260				
	Guadalupe River @ Alviso Hwy 237	170.64	30112	21684	21699	22120				

*For Upper Guadalupe Watershed Only

The results show a very remarkable similarity at every point except at Guadalupe Creek below the dam. The big deviation at this point is expected because the time to peak in the 72-hour storm distribution is greater than the 24-hour storm, and the 72-hour storm distribution has less volume in front of the peak than the 24-hour storm distribution. The Guadalupe Reservoir could not fill to capacity from the inflow hydrograph, and the resulting low outflow is entirely through the outlet works. But that deviation is relatively small if compared to the total flow in the river (920 cfs. outflow for 244R and 240 cfs. for 72 hours, as per the river flow of 12,000 cfs.)

The Northern California Coastal Streams' storm distribution has been used by the District in the past hydrologic studies. The Santa Clara Valley is situated where it could be affected by southern storms as well as the northern; therefore, analysis was made to test if the Southern California Coastal Streams' storm distribution would produce a more critical flood. Flows were compiled based on 1976 SCVWD Regional Regression Equations. Coincident frequency analyses for the reservoirs with the Northern California Coastal Streams' storm distribution and the Southern California Coastal Streams' storm distribution on the Upper Guadalupe watershed were calculated; respective flows were generated for every storm. The results of comparison are tabulated in Table 1-7. The flows produced from the Southern California Coastal Streams' storm distribution are insignificantly higher than the flows produced from the Northern California Coastal Streams' storm distribution.

As shown in Table 1-7, the maximum deviations occurred between the outflow of Almaden Reservoir and the Alamitos Creek near New Almaden. This deviation is within an acceptable 15 percent difference, while other points compared more closely. The Northern California Coastal Streams' storm distribution, which was used in adjacent areas in the county, was therefore used here, noting that it is similar to the distribution of the 1958 storm within this area.

TABLE 1-7

GUADALUPE RIVER HYDROLOGY

COMPARISON OF

NORTHERN CALIFORNIA WITH THE SOUTHERN CALIFORNIA STORM DISTRIBUTIONS

	Location	Drainage Area (Square Miles)	24-Hrs. Storm, Bal. With Peak & 24-Hr Floods	
			Northern California Storm Distribution	Southern California Storm Distribution
UPPER GUADALUPE Watershed	Inflow to Calero Reservoir	6.99	2594	2594
	Outflow from Calero Reservoir	6.99	633	536
	Inflow to Almaden Reservoir	12.00	4385	4417
	Outflow from Almaden Reservoir	12.00	3508	3897
	Alamitos Crk @ Greystone Lane	33.80	7804	8900
	Golf Crk U/S of Alamitos Creek	3.08	1171	1177
	Alamitos Crk Below Golf Creek	36.88	8552	9624
	Alamitos Crk near New Almaden	37.96	8858	10040
	Inflow to Guadalupe Reservoir	5.96	2349	2349
	Outflow from Guadalupe Reservoir	5.96	921	1009
	Guadalupe Crk @ Los Gatos Golf Course	12.71	2781	2782
	Guadalupe Creek @ Alamitos Creek	15.24	2967	3167
	Guadalupe Creek @ Alamitos Perc Ponds	53.20	11778	13111
LOWER GUADALUPE	Ross Creek @ Guadalupe River	9.96	1934	
	Canoas Creek U/S of Guadalupe River	18.62	2351	No comparison was made for lower Guadalupe watershed.
	Guadalupe River Below Canoas Creek	88.60	16508	
	Inflow to Lexington Reservoir	37.52	11145	
	Los Gatos Creek Below Lexington	37.52	6690	
	Los Gatos Creek @ Guadalupe River	54.83	7976	
	Guadalupe River @ San Jose	150.13	19804	
	Guadalupe River @ Alviso Hwy 237	170.64	21684	

Special Consideration - Initial Reservoir Storages

The reservoirs in the Guadalupe watershed are operated as water conservation facilities but they do provide incidental flood protection since they might be less than full when a large storm occurs. Even a full reservoir will attenuate a flood peak to some degree.

Because there is a very good chance that a reservoir would not be full at the time the 1% design storm occurs, it was necessary to determine an initial reservoir level which would account for the compounded probabilities between the 1% inflow and reservoir storage, and give a realistic value for an outflow which would also have a 1% chance of occurring in any one year. The procedure used was developed by the Corps of Engineers and is documented in reference #1, Statistical Methods in Hydrology.

Operations of the reservoirs have been changed since 1963 and more extensively after 1968 when reservoirs were kept fuller more often for recreational and other uses. This is done by maintaining basic pools in the reservoirs throughout the year. Storage-Duration curves with various operation data are plotted for Calero, Almaden, and Guadalupe Reservoirs as shown in Figures 1-9, 1-10 and 1-11.

Coincident frequency analyses were done on different operations of reservoirs.

The finally adopted initial reservoir storages were based on the operation data from 1968 to 1976.

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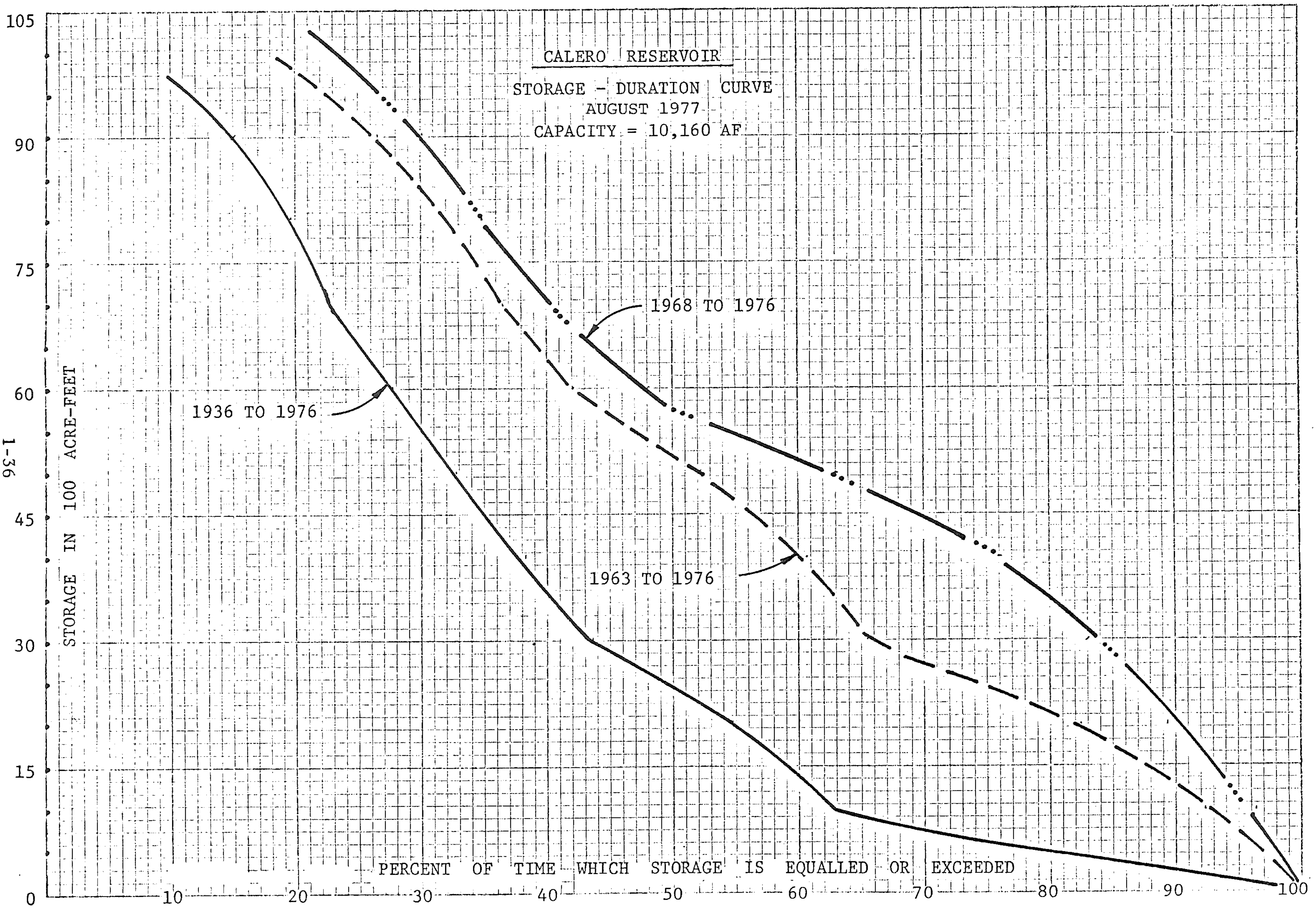

FIGURE 1-9

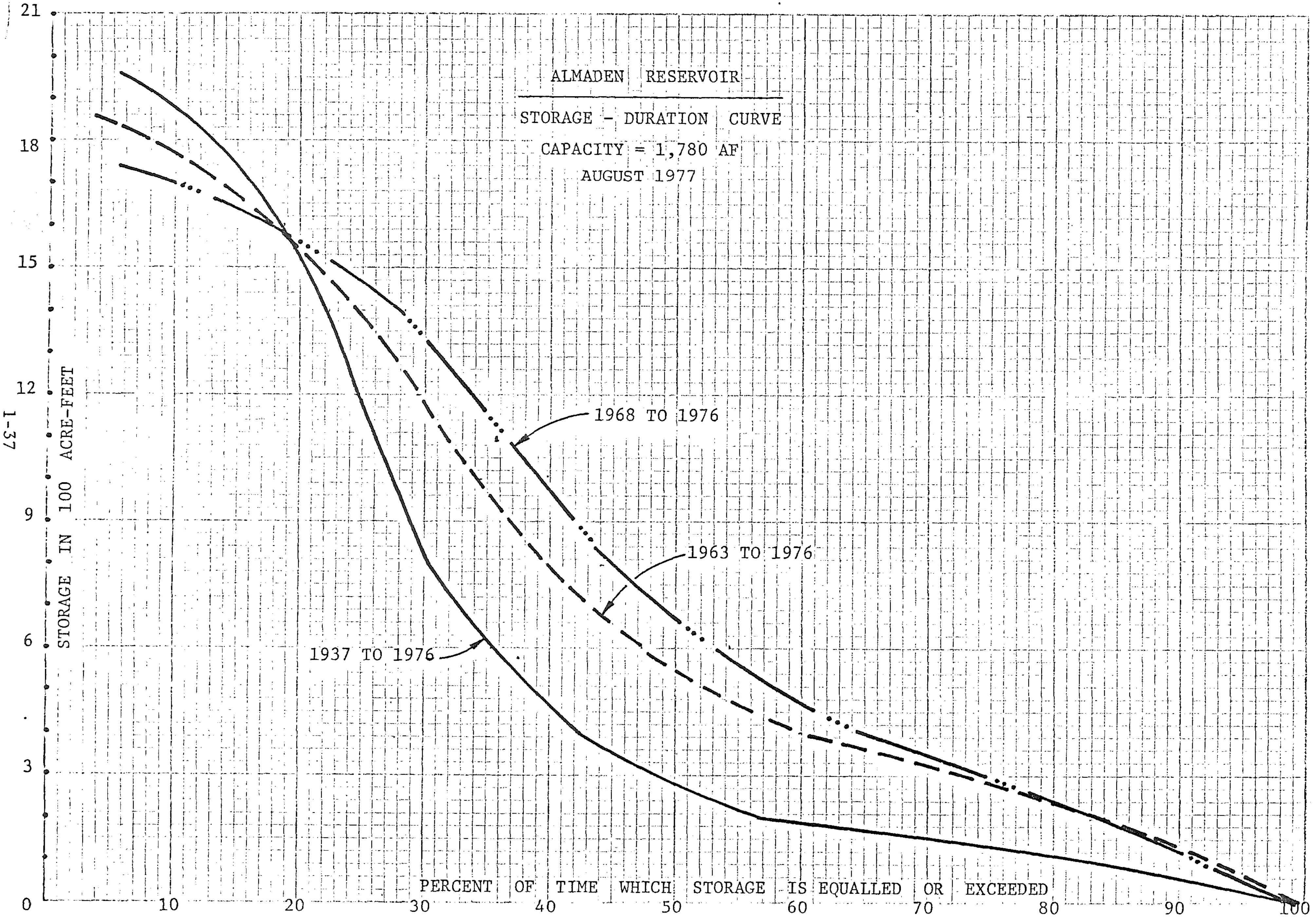
ALMADEN RESERVOIR
STORAGE - DURATION CURVE
CAPACITY = 1,780 AF
AUGUST 1977
1968 TO 1976
1963 TO 1976
1937 TO 1976
STORAGE IN 100 ACRE-FEET
PERCENT OF TIME WHICH STORAGE IS EQUALLED OR EXCEEDED
0
3
6
9
12
15
18
21
10
20
30
40
50
60
70
80
90
100

FIGURE 1-10

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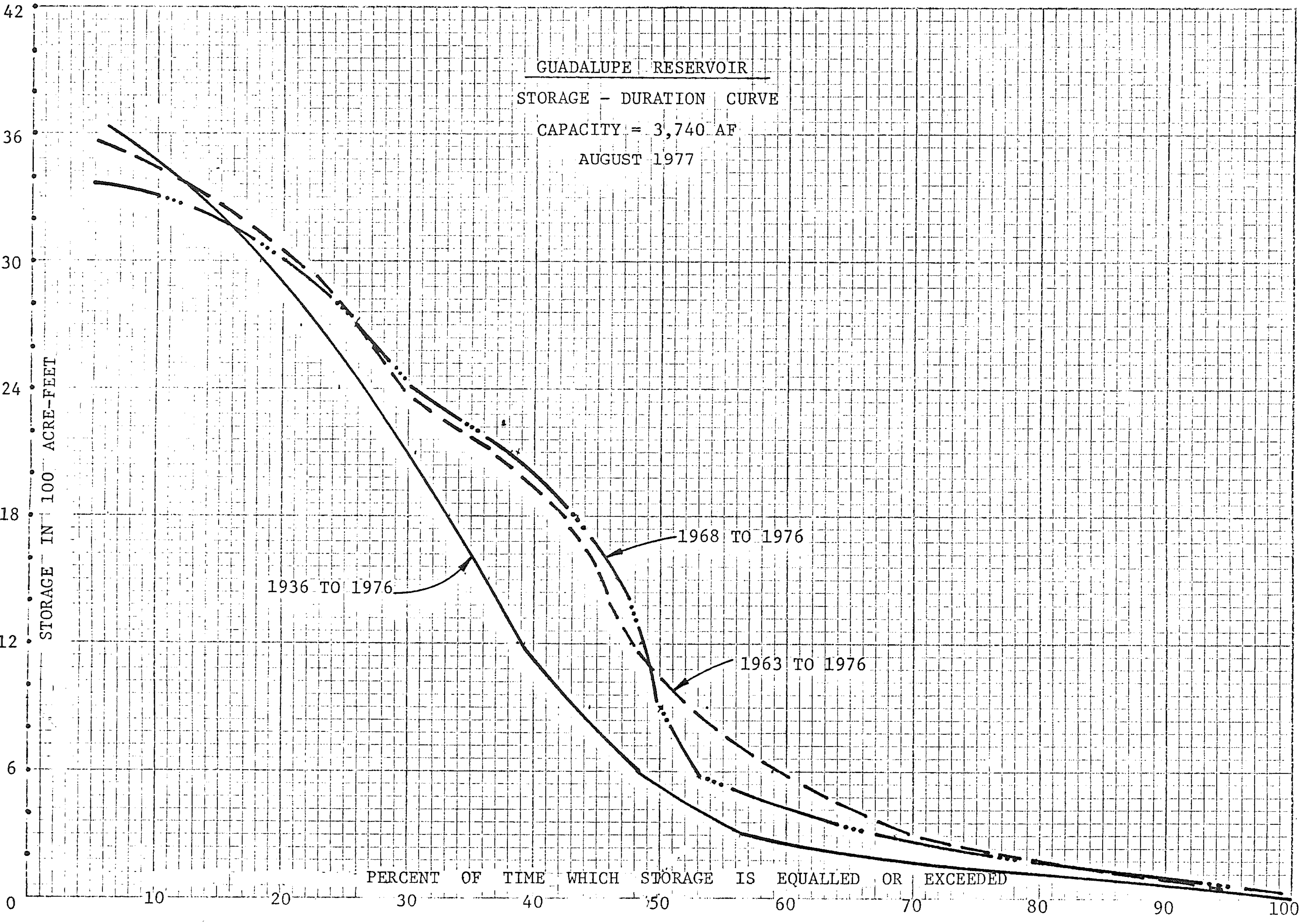

FIGURE 1-11

The initial reservoir storages used for the one percent and ten percent flows are given in the following tabulation:

Initial Reservoir Storages

	For the One Percent Flood		For the Ten Percent Flood	
Reservoir	AF	Percent of Capacity	AF	Percent of Capacity
Calero	9,300	92%	9,300	92%
Almaden	800	45%	900	51%
Guadalupe	2,900	78%	3,150	84%
Lake Elsman	6,150*	100%	6,150*	100%
Lexington	14,000	69%	15,000	74%
Vasona	410*	100%	410*	100%

*Assigned Values, no basic data available.

From the results it was noted that Calero Reservoir, with a greater storage capacity and a smaller relative drainage area than Almaden Reservoir and Guadalupe Reservoir, has a relatively higher storage level than expected.

A comparison was made between Calero Reservoir in full condition and the computed initial storage level of 9,300 AF. The downstream flow rates are tabulated as follows:

	Calero Full	Initial Storage= 9,300 AF	Percent Difference
Inflow to Calero	2,594	2,594	0%
Outflow from Calero	1,151	633	82%
Alamitos Creek D/S Golf Creek	9,032	8,552	6%
Confluence of Alamitos Creek and Guadalupe Creek	12,281	11,778	4%

Results indicate that the effect of the initial storage of Calero on Alamitos Creek is reduced at downstream locations. Assuming unregulated stream gage records represent independent events, an analysis of the records from gage USGS #167000 (Alamitos Creek newr New Almaden gage) yielded a 1 percent flow rate = 7,900 cfs which compares well with the flow computed at Alamitos Creek downstream of Golf Creek with Calero's initial storage of 9,600 AF. The result supports the computed initial storage of 9,300 AF for Calero Reservoir.

Almaden Reservoir was filled to spilling only about 6% of the time and is less than half full 60% of the time. Testing the sensitivity between an initial storage capacity of 800 AF (45%) in Almaden and a full reservoir produced only a small change (about 1%) in the outflow and did not affect downstream peak flows. This was expected because of its small storage capacity and a relatively large drainage area.

With 2,900 AF (78%) as the initial storage volume in Guadalupe Reservoir, the downstream flow rates are tabulated as follows:

Location	1% Flood (cfs)
Inflow to Guadalupe Reservoir	2,349
Outflow from Guadalupe Reservoir	921
Guadalupe Creek near Los Gatos Golf Course	2,781
Guadalupe Creek at Alamitos Creek	2,967

The Guadalupe Creek at Los Gatos Golf Course gage (now SCVWD #43) has continuous records since 1930. Records since 1935 have been affected by Guadalupe Reservoir which controls 43% of the drainage area at the gage. Since the storage capacity of the reservoir is relatively small, it was assumed to have minor effect on the peak flows at the gage. Statistical analysis of the annual peak discharges yields a 1% flow = 2,811 cfs which compares quite well with the tabulated values for Guadalupe Creek downstream of the reservoir as shown above.

For Lake Elsman, Lexington Reservoir and Vasona Reservoir see the Los Gatos Creek Hydrology Report following this study.

Other Studies - Past and Present

The hydrology of Guadalupe River has been studied several times in the past by the Corps of Engineers and the District. The design flow values currently listed in the 1972 Manual of Design Flows are from a 1970 study based on the application of outdated regional regression equations.

The District's current hydrologic study of Guadalupe River is based primarily on the application of 1976 SCVWD regional regression equations. The hundred-year return period peak flow rates have been determined for numerous points in the Guadalupe River Basin by several different methods: Regionally balanced hydrographs, rainfall generated hydrographs, statistical frequency analysis, and correlation and adjustment of statistics. The 1% flow rates from the regional regression are summarized in Talbes 1-8 and 1-9.

To further check the applicability of the 1976 SCVWD Regional Regression Equations to Guadalupe watershed, statistical analysis was made on the 24-hour volume. The maximum annual one-day streamflows from gaging stations USGS #1670, SCVWD #43, SCVWD #67, SCVWD #51, and USGS #1690 were extracted from the data and converted to 24-hour volume through the relationship $\text{Log } Q_{24\text{-hr.}} = .23 \text{ Log } Q_{\text{peak}} + .77 \text{ Log } Q_{\text{daily}}$ developed by the Corps of Engineers. The 24-hour volume data calculated is listed in Table 1-10. Results of the statistical analysis are tabulated on Table 1-11. This also shows a satisfactory comparison (for Ross Creek, see Refernce 3) which concluded that the 24-hour storm with the Northern California Coastal Streams' storm distribution, together with the 1976 SCVWD Regional Regression Equations, is the best combination used in this study under present circumstances.

Due to changes which have occurred in the study area since the previous hydrologic studies were conducted, the Corps of Engineers made a new independent hydrologic study on the Guadalupe River Basin. (Hydrologic Engineering Office Report, Guadalupe River and Coyote Creek, June 1977 Preliminary Report.)

Table 1-12 summarizes and compares the 1% flow rates determined from the past and the present studies.

TABLE 1-8
UPPER GUADALUPE 1% FLOOD
1976 SCVWD REGIONAL EQUATIONS
COINCIDENT FREQUENCY RESERVOIR LEVEL

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA	
HYDROGRAPH AT	1	2594.	1683.	973.	479.	6.99	INFLOW TO CALERO RESERVOIR
ROUTED TO	1	633.	607.	421.	298.	6.99	OUTFLOW FROM CALERO RESERVOIR
ROUTED TO	2	626.	602.	421.	295.	6.99	
HYDROGRAPH AT	2	1137.	631.	349.	170.	2.65	
ROUTED TO	2	1137.	631.	349.	170.	2.65	ARROYO CALERO CREEK
2 COMBINED	2	1321.	906.	664.	465.	9.64	
HYDROGRAPH AT	2	859.	461.	253.	123.	1.99	
ROUTED TO	2	859.	461.	253.	123.	1.99	SANTA TERESA CREEK
2 COMBINED	2	2180.	1329.	897.	588.	11.63	
ROUTED TO	4	2063.	1329.	896.	587.	11.63	
HYDROGRAPH AT	4	375.	183.	99.	48.	0.76	
ROUTED TO	4	375.	183.	99.	48.	0.76	
2 COMBINED	4	2330.	1497.	989.	635.	12.39	
HYDROGRAPH AT	3	4385.	2851.	1764.	912.	12.00	INFLOW TO ALMADEN RESERVOIR
ROUTED TO	3	3508.	2790.	1291.	740.	12.00	OUTFLOW FROM ALMADEN RESERVOIR
ROUTED TO	4	3213.	2769.	1291.	736.	12.00	
HYDROGRAPH AT	4	1720.	1023.	580.	283.	4.24	
ROUTED TO	4	1720.	1023.	580.	283.	4.24	
2 COMBINED	4	4748.	3675.	1788.	1020.	16.24	
2 COMBINED	4	6750.	5105.	2767.	1655.	28.63	
ROUTED TO	5	6584.	5106.	2766.	1654.	28.63	
HYDROGRAPH AT	5	338.	164.	89.	43.	0.74	
ROUTED TO	5	338.	164.	89.	43.	0.74	
2 COMBINED	5	6750.	5231.	2847.	1697.	29.37	
HYDROGRAPH AT	5	932.	522.	289.	140.	2.28	
ROUTED TO	5	932.	522.	289.	140.	2.28	RANDOL CREEK
2 COMBINED	5	7378.	5672.	3119.	1837.	31.65	
ROUTED TO	6	7252.	5671.	3119.	1836.	31.65	
HYDROGRAPH AT	6	334.	164.	90.	44.	0.77	
ROUTED TO	6	334.	164.	90.	44.	0.77	
2 COMBINED	6	7427.	5801.	3203.	1880.	32.42	
HYDROGRAPH AT	6	640.	334.	183.	88.	1.38	
ROUTED TO	6	640.	334.	183.	88.	1.38	GREYSTONE CREEK
2 COMBINED	6	7804.	6087.	3374.	1968.	33.80	
ROUTED TO	7	7688.	6077.	3372.	1966.	33.80	
HYDROGRAPH AT	7	1171.	665.	375.	183.	3.08	
ROUTED TO	7	1171.	665.	375.	183.	3.08	GOLF CREEK
2 COMBINED	7	8552.	6681.	3731.	2149.	36.89	
HYDROGRAPH AT	7	296.	124.	73.	35.	0.53	
ROUTED TO	7	296.	124.	73.	35.	0.53	
2 COMBINED	7	8682.	6791.	3798.	2184.	37.41	
ROUTED TO	10	8711.	6780.	3798.	2180.	37.41	
HYDROGRAPH AT	10	300.	134.	74.	36.	0.55	
ROUTED TO	10	300.	134.	74.	36.	0.55	
2 COMBINED	10	8858.	6892.	3868.	2216.	37.96	
HYDROGRAPH AT	8	2349.	1417.	844.	416.	5.96	INFLOW TO GUADALUPE RESERVOIR
ROUTED TO	8	921.	811.	399.	311.	5.96	OUTFLOW FROM GUADALUPE RESERVOIR
ROUTED TO	9	903.	795.	399.	309.	5.96	
HYDROGRAPH AT	9	2547.	1425.	844.	422.	6.75	
ROUTED TO	9	2547.	1425.	844.	422.	6.75	
2 COMBINED	9	2781.	1905.	1234.	731.	12.71	
ROUTED TO	10	2077.	1862.	1218.	722.	12.71	
HYDROGRAPH AT	10	1120.	607.	340.	165.	2.53	
ROUTED TO	10	1120.	607.	340.	165.	2.53	
2 COMBINED	10	2967.	2372.	1541.	887.	15.24	
2 COMBINED	10	11778.	9262.	5409.	3103.	53.20	CONFLUENCE OF GUADALUPE CREEK AND ALAMITOS CREEK

TABLE 1-9

LOWER GUADALUPE 1% FLOOD
1976 SCVWD REGIONAL EQUATIONS
COINCIDENT FREQUENCY RESERVOIR LEVEL

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA	
HYDROGRAPH AT	1	11778	9261	5409	3103	53.20	CONFLUENCE OF GUADALUPE & ALAMITOS
ROUTED TO	2	11761	9262	5404	3099	53.20	
HYDROGRAPH AT	2	373	242	150	73	1.00	
HYDROGRAPH AT	2	289	217	120	58	1.09	
2 COMBINED	2	658	454	268	131	2.09	
ROUTED TO	2	234	233	225	131	2.09	
2 COMBINED	2	11989	9494	5626	3229	55.29	
HYDROGRAPH AT	2	1934	1636	1254	718	9.96	ROSS CREEK
2 COMBINED	2	13923	11100	6680	3947	65.25	
ROUTED TO	3	13747	11090	6878	3942	65.25	GUADALUPE BELOW ROSS CREEK
HYDROGRAPH AT	3	924	672	422	206	2.84	
HYDROGRAPH AT	3	485	372	208	101	1.89	
2 COMBINED	3	1394	1043	628	307	4.73	
ROUTED TO	3	533	532	511	307	4.73	
2 COMBINED	3	14268	11615	7384	4249	69.98	
HYDROGRAPH AT	4	650	457	288	141	1.91	
HYDROGRAPH AT	4	639	508	294	144	2.65	
2 COMBINED	4	1203	956	578	286	4.56	
ROUTED TO	4	509	508	489	286	4.56	
ROUTED TO	5	509	507	488	286	4.56	
HYDROGRAPH AT	5	333	214	133	64	.87	
HYDROGRAPH AT	5	511	391	221	108	1.98	
2 COMBINED	5	784	597	351	172	2.85	
ROUTED TO	5	318	317	303	172	2.85	
2 COMBINED	5	826	824	790	458	7.41	
ROUTED TO	6	826	824	790	458	7.41	
HYDROGRAPH AT	6	674	481	303	149	2.05	
HYDROGRAPH AT	6	357	268	150	73	1.36	
2 COMBINED	6	995	748	452	221	3.41	CANOAS CREEK
ROUTED TO	6	384	383	368	221	3.41	
HYDROGRAPH AT	6	293	198	124	60	.83	
HYDROGRAPH AT	6	232	170	95	46	.86	
2 COMBINED	6	507	366	217	106	1.69	
ROUTED TO	6	189	188	181	106	1.69	
3 COMBINED	6	1399	1395	1339	786	12.51	
ROUTED TO	7	1399	1394	1338	786	12.51	
HYDROGRAPH AT	7	912	684	434	214	3.02	
HYDROGRAPH AT	7	502	385	217	106	2.02	
2 COMBINED	7	1373	1068	650	320	5.04	
ROUTED TO	7	564	563	541	320	5.04	
2 COMBINED	7	1963	1957	1879	1105	17.55	
ROUTED TO	3	1963	1956	1879	1105	17.55	
HYDROGRAPH AT	3	470	273	150	73	1.07	
ROUTED TO	3	470	273	150	73	1.07	
2 COMBINED	3	2351	2161	2004	1178	18.62	
2 COMBINED	3	16508	13772	9354	5427	88.60	GUADALUPE BELOW CANOAS
ROUTED TO	8	16104	13747	9350	5420	88.60	
HYDROGRAPH AT	8	774	554	344	168	2.42	
HYDROGRAPH AT	8	270	202	110	53	1.04	
2 COMBINED	8	1026	755	453	221	3.46	
ROUTED TO	8	388	387	373	221	3.46	
2 COMBINED	8	16484	14130	9721	5641	92.06	

TABLE 1-9 (continued)

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 ROUTED TO          9   16115   14124    9719    5632    92.06
 HYDROGRAPH AT      9     794     569     352     172     2.59
 HYDROGRAPH AT      9     157     120      66      32      .65
  2 COMBINED        9     947     687     417     204     3.24
 ROUTED TO          9     362     361     348     204     3.24
  2 COMBINED        9   16474   14482   10066    5836    95.30
 HYDROGRAPH AT      9    7976    7454    4443    2738    54.63  LOS GATOS CREEK
  2 COMBINED        9   19804   18146   14082    8573   150.13   GUADALUPE BELOW LOS GATOS
 ROUTED TO         10   19811   18144   14082    8557   150.13
 HYDROGRAPH AT     10     819     596     370     181     2.60
 HYDROGRAPH AT     10     283     214     117      57     1.19
  2 COMBINED       10    1096     809     486     235     3.99
 ROUTED TO         10     442     440     423     238     3.99
  2 COMBINED       10   20249   18584   14487    8795   154.12
 ROUTED TO         11   20093   18575   14483    8769   154.12   GUADALUPE AT HIGHWAY 17
 HYDROGRAPH AT     11    1173     684     551     271     4.30
 HYDROGRAPH AT     11     408     319     175      85     1.03
  2 COMBINED       11    1565    1202     725     355     6.13
 ROUTED TO         11     675     673     642     356     6.13
  2 COMBINED       11   20764   19247   15096    9124   160.25
 ROUTED TO         12   20563   19208   15084    9076   160.25   GUADALUPE AT HIGHWAY 101
 HYDROGRAPH AT     12    1292    1004     625     307     5.00
 HYDROGRAPH AT     12    1059     883     498     244     5.39
  2 COMBINED       12    2309    1874    1119     551    10.39
 ROUTED TO         12    1131    1128    1034     551    10.39
  2 COMBINED       12   21684   20335   16059    9627   170.64   GUADALUPE AT ALVISO HIGHWAY 237
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TABLE 1-10

ANNUAL MAXIMUM *24-HOUR VOLUME (AVG. CFS)
GUADALUPE RIVER HYDROLOGY
AUGUST 1977

Water Year	Alamitos Creek U/S Guadalupe Creek USGS # 1670	Guadalupe Creek @ Los Gatos Golf Course SCVWD #43	Los Gatos Creek below Lexington Dam SCVWD # 67	Ross Creek below Jarvis Road SCVWD # 51	Guadalupe River @ San Jose USGS # 1690
1929					
1930		617	1589		3289
1931		22	99		
1932	1774	697	2311		4277
1933	103	122	346		145
1934	908	344	824		1575
1935	347	225	708		899
1936	191	93	926		702
1937	764	262	1854		2651
1938	1549	779	2050		4262
1939	42	47	329		192
1940	1395	457	4706		6160
1941	1303	532	1973		3507
1942		215	1882		2643
1943		319	2842		3737
1944	199	115	1057		1562
1945	1216	343			4984
1946	194	88			1011
1947	30	42			228
1948	45	80			313
1949	178	149			1564
1950	54	47			787
1951	275	135			1739
1952	1511	663			
1953	154	106			
1954	61	88			
1955	97	86			
1956	3231	811			
1957	155	132		61	
1958		1310		212	
1959		242			
1960				12	
1961		11		60	
1962		233		195	
1963		857		357	
1964		116		383	
1965		142		136	
1966		52		52	
1967		1132		278	
1968		379		603	
1969		517		368	
1970		119		129	
1971		129		295	
1972		48		66	
1973		404			
1974		158		191	
1975		93		163	
1976		16		63	

* Maximum Annual 1-Day streamflows were extracted from data and converted to 24-hour volume through the relationship.

$$\text{Log } Q_{24} = .23 \text{ Log } Q_{peak} + .77 \text{ Log } Q_{daily}$$

TABLE 1-11
1% 24-HOUR FLOOD VOLUMES
GUADALUPE RIVER HYDROLOGY
AUGUST 1977

Station	Year of Record	Drainage Area Square Miles	Mean	Standard Deviation	Weighted Skew Coefficient	24-Hour Volume (average CFS)	Regional Results (average CFS)
Alamitos Creek near Edenvale USGS # 1670	1932-1957	34.6	2.4608	0.6079	-0.6400	3854	3731
Guadalupe Creek @ Los Gatos Golf Course SCVWD # 67	1930-1976	12.7	2.2367	0.4872	-0.5391	1496	1234
Los Gatos Creek below Lexington Dam SCVWD #67	1930-1944	38.6	3.0433	0.4326	-0.6400	6981	6019
Ross Creek below below Jarvis Road SCVWD #51	1957-1976	7.6	2.1515	0.4215	-0.6400	854	1254
Guadalupe River @ San Jose USGS # 1690	1930-1951	144.0	3.1454	0.4900	-0.6400	11279	14082

TABLE 1-12

GUADALUPE RIVER HYDROLOGY

1% Flood (cfs)

Comparison of Results August 1977

	Location	Drainage Area (Square Miles)	Previous Design Flow (Green Book)	Frequency Analysis Recorded Data Only			Corps of Engineers Guadalupe and Coyote Report Dated June '77	SCVWD 1976 Regional Equations
				Station Number	D. A. (Sq. Mi)	1% Flow		
Upper Guadalupe Watershed	Inflow to Calero Reservoir	6.99					2900	2594
	Outflow from Calero Reservoir	6.99	1000				720	633
	Inflow to Almaden Reservoir	12.00					5100	4385
	Outflow from Almaden Reservoir	12.00	4600				4800	3508
	Alamitos Crk @ Greystone Lane	33.80	7500	USGS 1670	35.0	7900		7804
	Golf Crk U.S of Alamitos Creek	3.08	1100	SCVWD 18	2.2	620		1171
	Alamitos Crk Below Golf Creek	36.88						8552
	Alamitos Crk near New Almaden	37.96	7600				8700	8858
	Inflow to Guadalupe Reservoir	5.96					2600	2349
	Outflow from Guadalupe Reservoir	5.96	3500				1700	921
	Guadalupe Crk @ Los Gatos Golf Course	12.71	7500	SCVWD 43	13.8	2811		2781
	Guadalupe Creek @ Alamitos Creek	15.24	7900				3500	2967
Lower Guadalupe	Guadalupe Creek @ Alamitos Perc Ponds	53.20	13000				11400	11778
	Ross Creek @ Guadalupe River	9.96	2250	SCVWD 51	9.2	2304	2950	1934
	Canoas Creek U/S of Guadalupe River	18.62	1900					2351
	Guadalupe River Below Canoas Creek	88.60	16000				14600	16508
	Inflow to Lexington Reservoir	37.52		SCVWD 67	38.6	12301	15500	11145
	Los Gatos Creek Below Lexington	37.52					7500	6690
	Los Gatos Creek @ Guadalupe River	54.83	14000				7800	7976
	Guadalupe River @ San Jose	150.13	24000	USGS 1690	144.0	16312	17000 (D.A. 144 Mi^2)	19804
	Guadalupe River @ Alviso Hwy 237	170.64						21684

Even though the procedures used by the Corps of Engineers and the District are quite different, the results of their studies are quite similar. Further, the statistical frequency analysis supports these values.

Discussion of Results

Alamitos Creek controls 71% of the drainage area at the confluence with Guadalupe Creek, yet according to the 1972 Manual of Design Flows, it contributes less flow than Guadalupe Creek (7,600 cfs for Alamitos Creek near New Almaden and 7,900 cfs for Guadalupe Creek upstream of Alamitos Creek). The second-feet per square mile (C.S.M.) values based on the green manual give 200 and 518, respectively. Alamitos Creek value might be a little low, but 518 C.S.M. for Guadalupe Creek definitely appears to be too high in comparison. The current study shows a more realistic peak of 8,858 cfs for Alamitos Creek and 2,967 cfs for Guadalupe Creek. These values yield 233 C.S.M. for Alamitos Creek and 195 C.S.M. for Guadalupe near New Almaden Creek. The statistical analysis yielded 8,700 cfs for Alamitos Creek and 2,811 cfs for Guadalupe Creek at Los Gatos Golf Course, which further supports these values.

The Corps of Engineers' values above the Guadalupe-Alamitos confluence compares quite well with the current study. At most points, the deviations are within a few percent. However, the most serious deviations are the outflows of Almaden Reservoir and Guadalupe Reservoir. These deviations might be from the different procedures used and the choice of different initial reservoir water levels, but the statistical analyses at gages downstream of reservoirs support the values used in this study.

The comparison of one percent flow rate at a location downstream of Los Gatos Confluence obtained from this study (19,804 cfs, which is 132 C.S.M.) and the one percent flow obtained from the statistical analysis of the data from Guadalupe River at San Jose gage for the unregulated period of record (1930-1951) revealed a lower one percent value of 16,312 cfs (113 C.S.M.). The statistical analysis of the continuous records (1930-1975) for Guadalupe River at San Jose gage yielded a one percent flow rate of 15422 cfs. Since the unregulated period of record at this gage is short and the continous records do not represent independent natural events, the lower values derived from statistical analysis are not considered indicative of the one percent flow rates. Because the regional results were used all over the upper and lower watersheds satisfactorily, the higher one percent flow rate of 19,804 cfs at Guadalupe River below the confluence with Los Gatos Creek is a more realistic value and is considered the best alternative.

Conclusions and Recommendations

This report is the summary of the work completed in the hydrologic study of Guadalupe River.

The flow rates developed from the 1976 SCVWD Regional Regression Equations and checked with recorded data, compare quite favorably with those summarized in the Corps of Engineers' 1977 hydrologic report and the 1972 FPI study.

The coincident frequency water levels of all the reservoirs in the watershed were determined following the procedure outlined in the Corps of Engineers' Statistical Methods in Hydrology.

After careful consideration of all available information, it is recommended that the flow rates derived from the application of 1976 SCVWD Regional Regression Equations and the coincident frequency reservoirs' levels be used for design purposes. The recommended one percent design flows are summarized in Table 1-13 along with the ten percent design flows in Table 1-14. The values in these tables should be rounded up to significant figures. These flows should supersede those listed in the 1972 manual for design purposes in the Guadalupe River Basin.

TABLE 1-13

GUADALUPE RIVER
RECOMMENDED 1% FLOOD FLOWS
AUGUST 1977

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA	
HYDROGRAPH AT	1	2594.	1683.	973.	479.	6.99	INFLOW TO CALERO RESERVOIR
ROUTED TO	1	633.	607.	421.	298.	6.99	OUTFLOW FROM CALERO RESERVOIR
ROUTED TO	2	626.	602.	421.	295.	6.99	
HYDROGRAPH AT	2	1137.	631.	349.	170.	2.65	
ROUTED TO	2	1137.	631.	349.	170.	2.65	ARROYO CALERO CREEK
2 COMBINED	2	1321.	906.	664.	465.	9.64	
HYDROGRAPH AT	2	859.	461.	253.	123.	1.99	
ROUTED TO	2	859.	461.	253.	123.	1.99	SANTA TERESA CREEK
2 COMBINED	2	2180.	1329.	897.	588.	11.63	
ROUTED TO	4	2063.	1329.	896.	587.	11.63	
HYDROGRAPH AT	4	375.	183.	99.	48.	0.76	
ROUTED TO	4	375.	183.	99.	48.	0.76	
2 COMBINED	4	2330.	1497.	989.	635.	12.39	
HYDROGRAPH AT	3	4385.	2851.	1764.	912.	12.00	INFLOW TO ALMADEN RESERVOIR
ROUTED TO	3	3508.	2790.	1291.	740.	12.00	OUTFLOW FROM ALMADEN RESERVOIR
ROUTED TO	4	3213.	2769.	1291.	736.	12.00	
HYDROGRAPH AT	4	1720.	1023.	580.	283.	4.24	
ROUTED TO	4	1720.	1023.	580.	283.	4.24	
2 COMBINED	4	4748.	3675.	1788.	1020.	16.24	
2 COMBINED	4	6750.	5105.	2767.	1655.	28.63	
ROUTED TO	5	6584.	5106.	2766.	1654.	28.63	
HYDROGRAPH AT	5	338.	164.	89.	43.	0.74	
ROUTED TO	5	338.	164.	89.	43.	0.74	
2 COMBINED	5	6750.	5231.	2847.	1697.	29.37	
HYDROGRAPH AT	5	932.	522.	289.	140.	2.28	
ROUTED TO	5	932.	522.	289.	140.	2.28	RANDOL CREEK
2 COMBINED	5	7378.	5672.	3119.	1837.	31.65	
ROUTED TO	6	7252.	5671.	3119.	1836.	31.65	
HYDROGRAPH AT	6	334.	164.	90.	44.	0.77	
ROUTED TO	6	334.	164.	90.	44.	0.77	
2 COMBINED	6	7427.	5801.	3203.	1880.	32.42	
HYDROGRAPH AT	6	640.	334.	183.	88.	1.38	
ROUTED TO	6	640.	334.	183.	88.	1.38	GREYSTONE CREEK
2 COMBINED	6	7804.	6087.	3374.	1968.	33.80	
ROUTED TO	7	7688.	6077.	3372.	1966.	33.80	
HYDROGRAPH AT	7	1171.	665.	375.	183.	3.08	
ROUTED TO	7	1171.	665.	375.	183.	3.08	GOLF CREEK
2 COMBINED	7	8552.	6681.	3731.	2149.	36.88	
HYDROGRAPH AT	7	296.	124.	73.	35.	0.53	
ROUTED TO	7	296.	124.	73.	35.	0.53	
2 COMBINED	7	8682.	6791.	3798.	2184.	37.41	
ROUTED TO	10	8711.	6780.	3798.	2180.	37.41	
HYDROGRAPH AT	10	300.	134.	74.	36.	0.55	
ROUTED TO	10	300.	134.	74.	36.	0.55	
2 COMBINED	10	8858.	6892.	3868.	2216.	37.96	
HYDROGRAPH AT	8	2349.	1417.	844.	416.	5.96	INFLOW TO GUADALUPE RESERVOIR
ROUTED TO	8	921.	811.	399.	311.	5.96	OUTFLOW FROM GUADALUPE RESERVOIR
ROUTED TO	9	903.	795.	399.	309.	5.96	
HYDROGRAPH AT	9	2547.	1425.	844.	422.	6.75	
ROUTED TO	9	2547.	1425.	844.	422.	6.75	
2 COMBINED	9	2781.	1905.	1234.	731.	12.71	
ROUTED TO	10	2077.	1862.	1218.	722.	12.71	
HYDROGRAPH AT	10	1120.	607.	340.	165.	2.53	
ROUTED TO	10	1120.	607.	340.	165.	2.53	
2 COMBINED	10	2967.	2372.	1541.	887.	15.24	
2 COMBINED	10	11778.	9262.	5409.	3103.	53.20	CONFLUENCE OF GUADALUPE CREEK AND ALAMITOS CREEK

TABLE 1-13 (continued)

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA	
HYDROGRAPH AT	1	11778	9261	5409	3103	53.20	CONFLUENCE OF GUADALUPE & ALAMITOS
ROUTED TO	2	11761	9262	5404	3099	53.20	
HYDROGRAPH AT	2	373	242	150	73	1.00	
HYDROGRAPH AT	2	289	217	120	58	1.09	
2 COMBINED	2	658	454	268	131	2.09	
ROUTED TO	2	234	233	225	131	2.09	
2 COMBINED	2	11989	9494	5626	3229	55.29	
HYDROGRAPH AT	2	1934	1636	1254	718	9.96	ROSS CREEK
2 COMBINED	2	13923	11100	6680	3947	65.25	
ROUTED TO	3	13747	11090	6878	3942	65.25	GUADALUPE BELOW ROSS CREEK
HYDROGRAPH AT	3	924	672	422	206	2.84	
HYDROGRAPH AT	3	485	372	208	101	1.69	
2 COMBINED	3	1394	1043	628	307	4.73	
ROUTED TO	3	533	532	511	307	4.73	
2 COMBINED	3	14268	11615	7384	4249	69.98	
HYDROGRAPH AT	4	650	457	288	141	1.91	
HYDROGRAPH AT	4	639	508	294	144	2.65	
2 COMBINED	4	1203	956	578	286	4.56	
ROUTED TO	4	509	508	489	286	4.56	
ROUTED TO	5	509	507	488	286	4.56	
HYDROGRAPH AT	5	333	214	133	64	.87	
HYDROGRAPH AT	5	511	391	221	108	1.98	
2 COMBINED	5	784	597	351	172	2.85	
ROUTED TO	5	318	317	303	172	2.85	
2 COMBINED	5	826	824	790	458	7.41	
ROUTED TO	6	826	824	790	458	7.41	
HYDROGRAPH AT	6	674	481	303	149	2.05	
HYDROGRAPH AT	6	357	268	150	75	1.36	
2 COMBINED	6	995	748	452	221	3.41	CANOAS CREEK
ROUTED TO	6	384	383	368	221	3.41	
HYDROGRAPH AT	6	293	198	124	60	.83	
HYDROGRAPH AT	6	232	170	95	46	.86	
2 COMBINED	6	507	366	217	106	1.69	
ROUTED TO	6	189	188	181	106	1.69	
3 COMBINED	6	1399	1395	1339	786	12.51	
ROUTED TO	7	1399	1394	1338	786	12.51	
HYDROGRAPH AT	7	912	684	434	214	3.02	
HYDROGRAPH AT	7	502	385	217	106	2.02	
2 COMBINED	7	1373	1068	650	320	5.04	
ROUTED TO	7	564	563	541	320	5.04	
2 COMBINED	7	1963	1957	1879	1105	17.55	
ROUTED TO	3	1963	1956	1879	1105	17.55	
HYDROGRAPH AT	3	470	273	150	73	1.07	
ROUTED TO	3	470	273	150	73	1.07	
2 COMBINED	3	2351	2161	2004	1178	18.62	
2 COMBINED	3	16508	13772	9354	5427	88.60	GUADALUPE BELOW CANOAS
ROUTED TO	8	16104	13747	9350	5420	88.60	
HYDROGRAPH AT	8	774	554	344	168	2.42	
HYDROGRAPH AT	8	270	202	110	53	1.04	
2 COMBINED	8	1026	755	453	221	3.46	
ROUTED TO	8	388	387	373	221	3.46	
2 COMBINED	8	16484	14130	9721	5641	92.06	

TABLE 1-13 (continued)

ROUTED TO	9	16115	14124	9719	5632	92.06	
HYDROGRAPH AT	9	794	569	352	172	2.59	
HYDROGRAPH AT	9	157	120	66	32	.65	
2 COMBINED	9	947	687	417	204	3.24	
ROUTED TO	9	362	361	348	204	3.24	
2 COMBINED	9	16474	14482	10066	5836	95.30	
HYDROGRAPH AT	9	7976	7454	4443	2738	54.83	LOS GATOS CREEK
2 COMBINED	9	19804	18146	14082	8573	150.13	GUADALUPE BELOW LOS GATOS
ROUTED TO	10	19811	18144	14082	8557	150.13	
HYDROGRAPH AT	10	819	596	370	181	2.66	
HYDROGRAPH AT	10	283	214	117	57	1.19	
2 COMBINED	10	1076	809	486	235	3.99	
ROUTED TO	10	442	440	423	238	3.99	
2 COMBINED	10	20249	18584	14487	8795	154.12	GUADALUPE AT HIGHWAY 17
ROUTED TO	11	20093	18575	14483	8769	154.12	
HYDROGRAPH AT	11	1173	684	551	271	4.30	
HYDROGRAPH AT	11	408	319	175	85	1.05	
2 COMBINED	11	1565	1202	725	355	6.13	
ROUTED TO	11	675	673	642	356	6.13	
2 COMBINED	11	20764	19247	15096	9124	160.25	GUADALUPE AT HIGHWAY 101
ROUTED TO	12	20563	19208	15084	9076	160.25	
HYDROGRAPH AT	12	1292	1004	625	307	5.00	
HYDROGRAPH AT	12	1059	883	498	244	5.39	
2 COMBINED	12	2309	1874	1119	551	10.39	
ROUTED TO	12	1131	1128	1034	551	10.39	
2 COMBINED	12	21684	20335	16059	9627	170.64	GUADALUPE AT ALVISO HIGHWAY 237

TABLE 1-14

GUADALUPE RIVER

RECOMMENDED 10% FLOOD FLOWS

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA	
HYDROGRAPH AT	1	1174.	890.	449.	218.	6.99	INFLOW TO CALERO RESERVOIR
ROUTED TO	1	184.	184.	184.	183.	6.99	OUTFLOW FROM CALERO RESERVOIR
ROUTED TO	2	184.	184.	184.	181.	6.99	
HYDROGRAPH AT	2	474.	308.	148.	71.	2.65	
ROUTED TO	2	474.	308.	148.	71.	2.65	ARROYO CALERO CREEK
2 COMBINED	2	657.	491.	331.	252.	9.64	
HYDROGRAPH AT	2	360.	225.	107.	52.	1.99	
ROUTED TO	2	360.	225.	107.	52.	1.99	SANTA TERESA CREEK
2 COMBINED	2	1017.	714.	437.	304.	11.63	
ROUTED TO	4	1017.	714.	437.	303.	11.63	
HYDROGRAPH AT	4	167.	95.	44.	21.	0.76	
ROUTED TO	4	167.	95.	44.	21.	0.76	
2 COMBINED	4	1179.	806.	481.	325.	12.39	
HYDROGRAPH AT	3	2277.	1740.	971.	494.	12.00	INFLOW TO ALMADEN RESERVOIR
ROUTED TO	3	1255.	1073.	496.	356.	12.00	OUTFLOW FROM ALMADEN RES.
ROUTED TO	4	1222.	1028.	496.	353.	12.00	
HYDROGRAPH AT	4	743.	524.	256.	124.	4.24	
ROUTED TO	4	743.	524.	256.	124.	4.24	
2 COMBINED	4	1430.	1189.	722.	476.	16.24	
2 COMBINED	4	2152.	1707.	1191.	801.	28.63	
ROUTED TO	5	2104.	1704.	1191.	800.	28.63	
HYDROGRAPH AT	5	153.	86.	40.	19.	0.74	
ROUTED TO	5	153.	86.	40.	19.	0.74	
2 COMBINED	5	2250.	1766.	1229.	820.	29.37	
HYDROGRAPH AT	5	414.	269.	129.	62.	2.28	
ROUTED TO	5	414.	269.	129.	62.	2.28	RANDOL CREEK
2 COMBINED	5	2664.	1978.	1353.	882.	31.65	
ROUTED TO	6	2610.	1977.	1353.	881.	31.65	
HYDROGRAPH AT	6	156.	89.	42.	20.	0.77	
ROUTED TO	6	156.	89.	42.	20.	0.77	
2 COMBINED	6	2715.	2045.	1394.	901.	32.42	
HYDROGRAPH AT	6	281.	170.	80.	39.	1.38	
ROUTED TO	6	281.	170.	80.	39.	1.38	GREYSTONE CREEK
2 COMBINED	6	2940.	2187.	1471.	939.	33.80	
ROUTED TO	7	2952.	2186.	1470.	937.	33.80	
HYDROGRAPH AT	7	503.	335.	162.	78.	3.08	
ROUTED TO	7	503.	335.	162.	78.	3.08	GOLF CREEK
2 COMBINED	7	3442.	2509.	1629.	1015.	36.88	
HYDROGRAPH AT	7	130.	69.	32.	15.	0.53	
ROUTED TO	7	130.	69.	32.	15.	0.53	
2 COMBINED	7	3527.	2573.	1660.	1031.	37.41	
ROUTED TO	10	3542.	2573.	1659.	1027.	37.41	
HYDROGRAPH AT	10	131.	68.	32.	15.	0.55	
ROUTED TO	10	131.	68.	32.	15.	0.55	
2 COMBINED	10	3626.	2638.	1690.	1042.	37.96	
HYDROGRAPH AT	8	1177.	867.	444.	216.	5.96	INFLOW TO GUADALUPE RESERVOIR
ROUTED TO	8	234.	234.	233.	230.	5.96	OUTFLOW FROM GUADALUPE RES.
ROUTED TO	9	234.	234.	233.	229.	5.96	
HYDROGRAPH AT	9	1219.	832.	436.	215.	6.75	
ROUTED TO	9	1219.	832.	436.	215.	6.75	
2 COMBINED	9	1450.	1063.	666.	444.	12.71	
ROUTED TO	10	1220.	1042.	657.	435.	12.71	
HYDROGRAPH AT	10	464.	302.	143.	69.	2.53	
ROUTED TO	10	464.	302.	143.	69.	2.53	
2 COMBINED	10	1683.	1323.	795.	504.	15.24	
2 COMBINED	10	5309.	3958.	2485.	1546.	53.20	CONFLUENCE OF GUADALUPE CREEK AND ALAMITOS CREEK

TABLE 1-14 (continued)

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA	
HYDROGRAPH AT	1	5309	3959	2485	1546	53.20	CONFLUENCE OF GUADALUPE & ALAMITOS
ROUTED TO	2	5220	3955	2483	1541	53.20	
HYDROGRAPH AT	2	251	161	96	47	1.00	
HYDROGRAPH AT	2	176	126	59	29	1.09	
2 COMBINED	2	407	284	155	75	2.09	
ROUTED TO	2	221	220	153	75	2.09	
2 COMBINED	2	5439	4174	2632	1616	55.29	
HYDROGRAPH AT	2	1291	1142	762	379	9.96	ROSS CREEK
2 COMBINED	2	6730	5316	3384	1996	65.25	
ROUTED TO	3	6702	5310	3380	1991	65.25	GUADALUPE BELOW ROSS CREEK
HYDROGRAPH AT	3	626	447	272	133	2.84	
HYDROGRAPH AT	3	293	217	103	50	1.89	
2 COMBINED	3	908	662	374	182	4.73	
ROUTED TO	3	501	499	367	182	4.73	
2 COMBINED	3	7200	5805	3742	2173	69.98	
HYDROGRAPH AT	4	438	304	186	91	1.91	
HYDROGRAPH AT	4	381	291	146	71	2.65	
2 COMBINED	4	759	588	329	162	4.56	
ROUTED TO	4	480	479	325	162	4.56	
ROUTED TO	5	480	478	324	162	4.56	
HYDROGRAPH AT	5	229	143	86	42	.87	
HYDROGRAPH AT	5	308	225	109	53	1.98	
2 COMBINED	5	491	362	193	94	2.85	
ROUTED TO	5	300	298	191	94	2.85	
2 COMBINED	5	779	776	514	256	7.41	
ROUTED TO	6	779	776	514	256	7.41	
HYDROGRAPH AT	6	452	320	195	96	2.05	
HYDROGRAPH AT	6	217	156	74	36	1.36	CANOAS CREEK
2 COMBINED	6	641	474	269	131	3.41	
ROUTED TO	6	361	360	264	131	3.41	
HYDROGRAPH AT	6	201	132	80	39	.83	
HYDROGRAPH AT	6	141	99	47	23	.86	
2 COMBINED	6	328	229	126	61	1.69	
ROUTED TO	6	178	178	124	61	1.69	
3 COMBINED	6	1319	1313	900	449	12.51	
ROUTED TO	7	1319	1312	898	449	12.51	
HYDROGRAPH AT	7	609	455	281	138	3.02	
HYDROGRAPH AT	7	303	223	108	52	2.02	
2 COMBINED	7	893	677	388	190	5.04	
ROUTED TO	7	532	530	382	190	5.04	
2 COMBINED	7	1850	1842	1279	639	17.55	
ROUTED TO	3	1850	1841	1277	639	17.55	
HYDROGRAPH AT	3	199	125	59	28	1.07	
ROUTED TO	3	199	125	59	28	1.07	
2 COMBINED	3	1991	1926	1335	668	18.62	
2 COMBINED	3	9191	7707	5076	2841	88.60	GUADALUPE BELOW CANOAS
ROUTED TO	8	9133	7696	5075	2834	88.60	
HYDROGRAPH AT	8	514	364	222	108	2.42	
HYDROGRAPH AT	8	162	115	54	26	1.04	
2 COMBINED	8	663	479	275	134	3.46	
ROUTED TO	8	366	365	270	134	3.46	
2 COMBINED	8	9498	8061	5340	2968	92.06	

TABLE 1-14 (continued)

ROUTED TO	9	9427	8057	5335	2959	92.06	
HYDROGRAPH AT	9	527	374	227	111	2.59	
HYDROGRAPH AT	9	94	69	32	16	.65	
2 COMBINED	9	619	442	259	126	3.24	
ROUTED TO	9	343	341	255	126	3.24	
2 COMBINED	9	9769	8398	5581	3086	95.30	
HYDROGRAPH AT	9	2175	1982	1448	1018	54.83	LOS GATOS CREEK
2 COMBINED	9	11883	10373	6810	4103	150.13	GUADALUPE BELOW LOS GATOS
ROUTED TO	10	11819	10367	6808	4088	150.13	
HYDROGRAPH AT	10	543	391	238	117	2.80	
HYDROGRAPH AT	10	170	123	58	28	1.19	
2 COMBINED	10	708	513	296	144	3.99	
ROUTED TO	10	420	419	292	144	3.99	
2 COMBINED	10	12238	10786	7086	4233	154.12	GUADALUPE AT HIGHWAY 17
ROUTED TO	11	12184	10766	7079	4208	154.12	
HYDROGRAPH AT	11	776	580	354	174	4.30	
HYDROGRAPH AT	11	243	183	87	42	1.83	
2 COMBINED	11	1009	762	441	216	6.13	
ROUTED TO	11	644	641	436	216	6.13	
2 COMBINED	11	12827	11407	7494	4424	160.25	GUADALUPE AT HIGHWAY 101
ROUTED TO	12	12615	11352	7463	4381	160.25	
HYDROGRAPH AT	12	856	661	404	198	5.[illegible]	
HYDROGRAPH AT	12	622	502	248	120	5.39	
2 COMBINED	12	1450	1154	649	318	10.39	
ROUTED TO	12	1084	1071	643	318	10.39	
2 COMBINED	12	13699	12407	8077	4699	170.64	GUADALUPE AT ALVISO HIGHWAY 237

Los Gatos Creek

Determination of Design Flows

CONTENTS

Page

General Information 2-2

Historic Events 2-4

Discussion of Procedures 2-7

Basin Characteristics and 1% Regional Flow 2-7
Recorded Data & Application of Regional Reg. Equations.. 2-8
Special Consideration - Reservoir Levels 2-14

Other Studies - Past and Present 2-19

Conclusions 2-21

TABLES

1 Records of Rainfall - Los Gatos Creek Watershed 2-6

2 Maximum Annual Peak Flow 1915 - 1975 Stream Gage Los Gatos Creek at Los Gatos 2-13

3 Los Gatos Creek Rainfall Generated Flows without Any Reservoirs 2-15

4 Los Gatos Creek 1976 Regional Regression Equations - Lexington Full 20,250 Acre-Feet 2-17

5 Los Gatos Creek 1976 Regional Regression Equations - Coincident Frequency Reservoir Level - Lexington at 14,000 Acre-Feet 2-18

6 Los Gatos Creek Recommended Design Flows - 1% Flood 2-24

7 Los Gatos Creek Ten-Year Flood Flows 2-25

FIGURES

1 Lost Gatos Creek below Lexington Dam, Flood Frequency 1930 - 1944 2-3

2 Los Gatos Creek at Los Gatos, Partial Duration Series Analysis 1953 - 1976 2-10

3 Los Gatos Creek below Lexington Dam Comparison of Frequency Analysis 2-20

4 Los Gatos Creek Flood Frequency 2-22

5 Los Gatos Creek Hydrology 2-26

PLATES

1 Los Gatos Creek Drainage Area 2-3

LOS GATOS CREEK HYDROLOGY

GENERAL INFORMATION

Los Gatos Creek originates at Loma Prieta Peak in the Santa Cruz Mountains. It flows down through several miles of steep canyon before merging onto the valley floor at Vasona Junction just below the Town of Los Gatos. The creek drains a total of 55 square miles at its confluence with the Guadalupe River in downtown San Jose (Figure 2-1). Most of the drainage basin lies in the high-rainfall area of the Santa Cruz Mountains. The basin receives an average annual rainfall ranging from 14 inches on the valley floor to over 50 inches on Loma Prieta, which is at an elevation of nearly 3,800 feet above sea level.

Except for the small diversion structure impounding Williams Reservoir (capacity less than 50 acre-feet), there are three principal reservoirs existing on Los Gatos Creek. The first and smallest is Vasona Reservoir (400 AF), built in 1935 by the Santa Clara Valley Water Conservation District. The second is Lake Elsman, constructed in 1950 by the San Jose Water Works in the upper reaches of the Los Gatos Creek drainage, where it impounds 6,150 acre-feet of water. The largest reservoir is Lexington, which was completed by the Santa Clara Valley Water Conservation District in 1952, and has a capacity of 20,100 acre-feet.

All the reservoirs were constructed for water conservation purposes and none is equipped or specifically operated for flood control purposes. However, some incidental flood control benefit is derived.

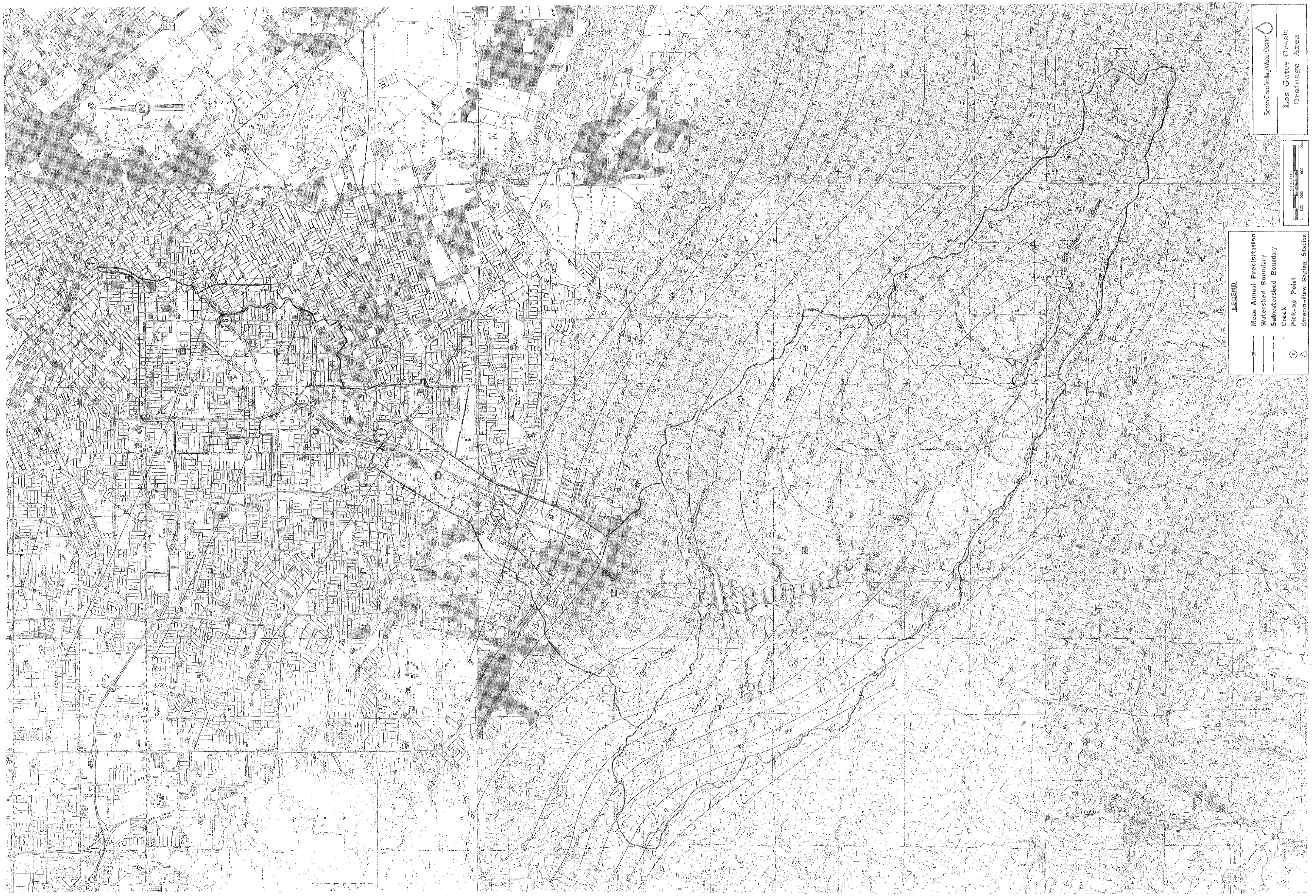

Santa Clara Valley Water District
Los Gatos Creek Drainage Area
SCALE IN FEET
0
1000
2000
4000
6000
LEGEND
Mean Annual Precipitation
Watershed Boundary
Subwatershed Boundary
Creek
Pick-up Point
Stream-flow Gaging Station
N
A
B
C
D
E
F
G
Los Gatos Creek
Trout Creek

Figure 2-1

HISTORIC EVENTS

The Los Gatos Creek has had a history of flooding. The most noteworthy, in the earliest days of the valley's growth, being the floods of the 1860's, as told in History of San Jose by James and McMurry:

> "The Los Gatos and Guadalupe Creeks overflowed in severe floods of March 1862 and December 20, 1867 -- in the latter the Los Gatos Creek cut out its present course...." "The severest flood of American times (February 8, 1869)...backed the waters four feet deep south of Santa Clara Street."

Certainly one of the greatest floods on Los Gatos Creek in the 20th century occurred March 7, 1911. The weekly Campbell Interurban Press described the flood in the March 10, 1911 issue under the headline; "Campbell Suffers Big Loss From Flood":

> "Waters of Los Gatos Creek Run Wild Through the Streets..." "The town of Campbell has been flooded... the appearance of a Venetian city..." "... a solid stream from the Los Gatos Road on the west to the interurban line on the east, one rushing torrent of water." "The railroad tracks from Campbell Avenue to near the bridge were all under water."

There have been large flows in more recent years and since 1930 these high flow rates have been recorded by the U. S. Geological Survey at a stream gage located just below the present Lexington Dam site (D.A. = 38.6 square miles).

Highest recorded flows before Lexington Dam (1930-1952)

1.	7100 cfs	January 27, 1940
2.	*5800 cfs	January 12, 1952
3.	*5600 cfs	February 1, 1945
4.	5500 cfs	February 13, 1937

Highest recorded flows after Lexington Dam (1952-1974)

1.	3540 cfs	April 2, 1958
2.	3530 cfs	March 16, 1967
3.	1660 cfs	February 2, 1963

The San Jose Mercury Herald provides a good account of the effects of some of these larger flows:

February 28, 1940

> ". . . Los Gatos Creek, only major north county stream not controlled by a storage dam, went on a solo rampage, destroying a 48-year-old diversion dam, undermining embankments and threatening bridges . . ."
>
> "The muddy water marked highest flow in the stream since 1911."

February 14, 1937

> "Ditch levees just below Page Dam, south of Campbell, gave way last night, spreading through orchards and driving several families from their homes . . ."

Flood flows in streams are affected by the combinations of prior rainfall, soil condition and available storage capacity. Under proper conditions, a storm of a certain intensity may cause a flood of larger size than what is expected. This is obvious as the dates of the maximum recorded one-day** rainfalls, compiled in Table 2-1 for several precipitation stations in the Los Gatos drainage, do not necessarily fall on the same days as the larger floods.

* Elsman Reservoir was constructed in 1950 and regulates 26% of the drainage area.

** One-day rainfall was used as it was readily available. The maximum 24-hour rainfall would be approximately 13% higher.

Table 2-1

Records of Rainfall
Los Gatos Creek Watershed

	Max. Annual Recorded 1-Day Rainfall		
#86 San Jose	1	4.32	Sept. 12, 1918
Elev - 95	2	3.77	Jan. 30, 1968
1907-1973	3	3.21	Oct. 13, 1962
#97 Seven Mile Reservoir	1	6.00	Oct. 12, 1962
Elev - 315	2	6.00	Jan. 31, 1963
1915 - 1973	3	4.60	Jan. 11, 1952
	4	4.40	Dec. 22, 1955
#58 Montevina Reservoir	1	8.45	Dec. 22, 1955
Elev - 696	2	7.10	Jan. 11, 1952
1915 - 1973	3	6.50	Jan. 31, 1963
#2 Alma College	1	8.10	Dec. 23, 1955
Elev - 900	2	8.08	Jan. 21, 1943
1916 - 1973	3	7.93	Jan. 31, 1963
#55 Millberry	1	10.25	Jan. 31, 1963
Elev - 1800	2	9.57	Dec. 23, 1955
1941 - 1972	3	7.45	Jan. 19, 1969

DISCUSSION OF PROCEDURES

Basin Characteristics and 1% Regional Flows

Los Gatos Creek watershed is divided into two major watersheds: rural, which includes subareas A, B, C and D, and urban, which includes subareas E, F and G (Figure 2-1). The subareas have the following basin characteristics:

	Sub-area	*Drainage Area (sq. mi.)	Mean Annual Precipitation (in.)	L/s ($mi^2/ft/ft^{1/2}$)	Tc (hours)
Los Gatos Creek at Lake Elsman	A	9.91	50	86	1.3
Los Gatos Creek at Lexington Reservoir	B	27.61	41	152	2.3
Los Gatos Creek at Vasona Reservoir	C	6.46	29	102	1.5
Los Gatos Creek at Camden Ave.	D	2.17	18	23	1.1
Los Gatos Creek at Highway 17	E	AI-1.58 AP-1.06	15.5	-	1.25 3.25
Los Gatos Creek at Meridian Ave.	F	AI-1.47 AP- .98	15	-	.92 2.90
Los Gatos Creek Upstream Guadalupe River	G	AI-2.15 AP-1.44	14	-	1.33 3.30

*AI = impervious urban area
AP = pervious urban area

In rural areas, the preliminary evaluation of design flows from regional regression equations is determined using the drainage areas, mean annual precipitation and basin factors. These preliminary values are compared with peak flows obtained from rainfall by employing the unit hydrograph theory and HEC-1 program. Although this latter technique is used mainly to define design hydrographs, the resultant peak flow is compared and balanced against the regional one. As will be shown later, the end result of the above procedure is further compared with results from the site specific analysis of recorded data if unavailable.

Urban areas are treated based on the District's method of urban hydrology. The density of land use is determined by the ratio of impervious to pervious parts.

Recorded Data and Application of Regional Regression Equations

Inherent in the District's hydrology methods are checking procedures that utilize additional data wherever available. Streamflow records, stochastically generated data, and data obtained from rainfall are utilized. Following is a discussion of all of these procedures and their application to Los Gatos Creek.

Streamflow Records

There are now, or have been in the past, a total of four stream gage stations located on Los Gatos Creek. One gage was formerly operated by the U.S.G.S. The Santa Clara Valley Water District operates the other three and now also operates the U.S.G,S. station.

U.S.G.S. (SCVWD #67)	Los Gatos Creek @ Los Gatos
SCVWD #19	Los Gatos Creek below Saratoga Avenue
SCVWD #59	Los Gatos Creek @ Lark Avenue
SCVWD #50	Los Gatos Creek @ Lincoln Avenue

All of these records were examined during the course of this hydrologic investigation and only the U.S.G.S. station

(SCVWD No. 67) was considered to be reliable enough for peak flood frequency analysis. All of the SCVWD gages were installed after Lexinton Dam was constructed in 1952 so their records are biased by regulation and cannot be readily used for statistical analysis.

The former USGS stream gage located just below Lexington Dam has a total of 44 yers of record, with the first fifteen reflecting a natural watershed (prior to 1944 when the gage was moved downstream). This station has been used as a base station in all regional frequency regression studies.

Analysis of the 15 years of unregulated flows produced the following statistics:

M = 3.261
σ = .441
g = -.6 (Regional Skew)
Q 1% = 12,304

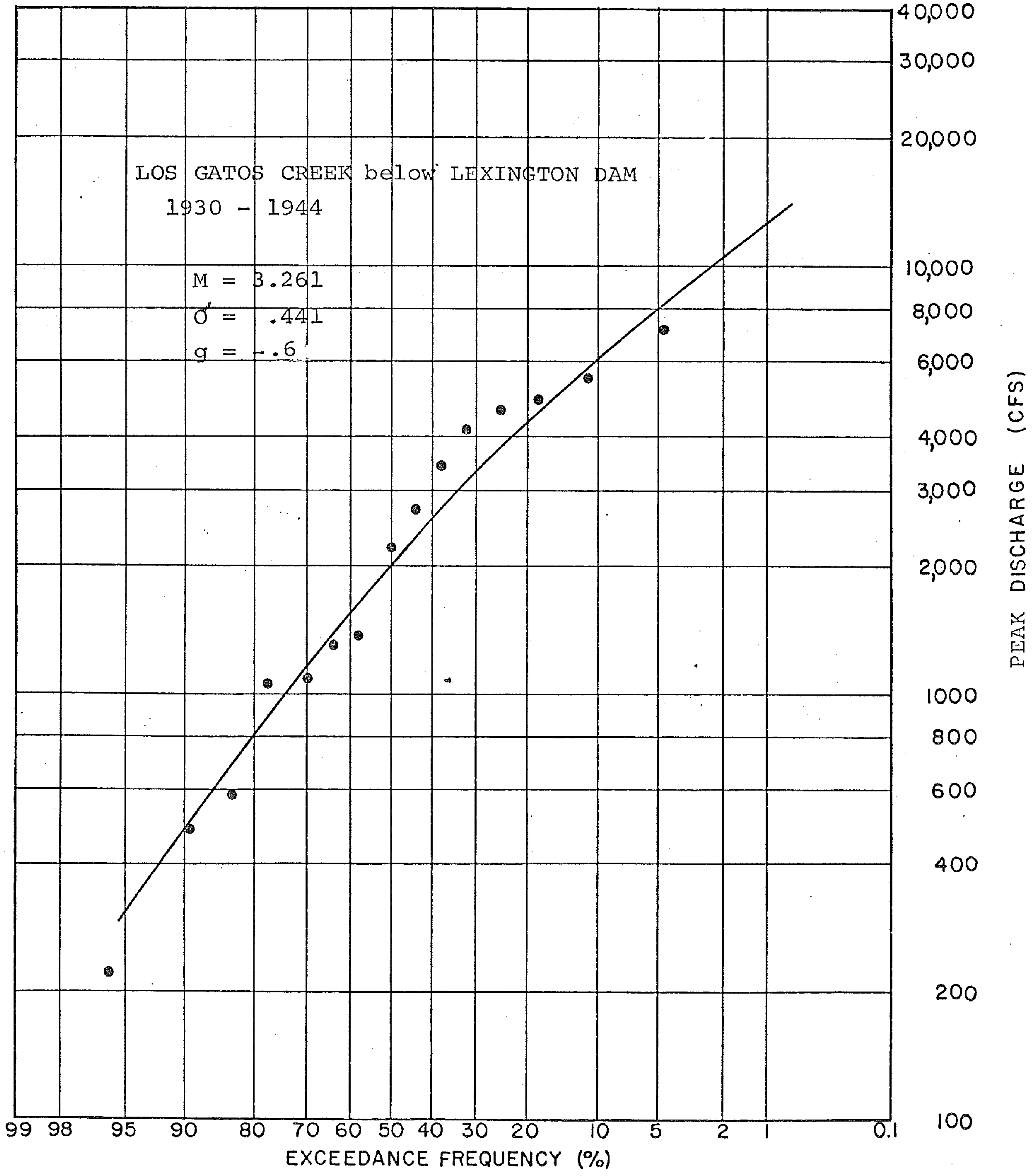
Each annual peak and the computed frequency curve are plotted in Figure 2-2.

Historic Data

Information about major floods which occurred before the period of systematic data collection can sometimes be used to make estimates of peak discharge. Use of historic data in addition to improving the frequency determinations assures that estimates fit community experiences.

At the time of the March 7, 1911 flood, Campbell residents were quoted as saying ". . . there was quite a flood 20 years ago but it did not compare with the present condition." The 7,110

August 1977



Data without regulation

FIGURE 2-2

cfs on February 27, 1940 was described as "The . . . highest flow in the stream since 1911." Therefore, the 1911 flood would be the highest flow observed in the 60 years prior to construction of the dams in 1950 and 1952, and the 7,110 cfs in 1940 would have been equalled or exceeded twice in those 60 years, making it about a 30-year or 3% flood. This estimate was used in computing the frequency curve on Figure 2-2, based on Water Resources Council guidelines.

The fifteen years of natural, unregulated streamflow records at the Los Gatos Creek gage (SCVWD #67) were correlated with the U.S.G.S. station at Saratoga which is in the basin immediately to the northwest and has continuous records since 1933. The procedure followed is the "Adjustments of Frequency Statistics" in the Corps of Engineers' Statistical Hydrology. The analysis gave an equivalent length of record of over 30 years, with a correlation coefficient of 0.89. Using the regional skewness of - .60, the 1% flood peak was estimated at 9,578 cfs.

There was some concern over the accuracy of the records kept by the U.S.G.S. at Los Gatos Creek and Saratoga Creek gages. During a phone conversation on January 31, 1975, Mr. Joe Robles of U.S.G.S. indicated that he had no reason to question any of the records at either station. He maintained his confidence in the records even when asked specifically about high flows. With the high statistical correlation and this confidence there is no need to suspect that the records are anything but good. However, additional correlation was done with the Arroyo Seco gage to supplement the results obtained from the Saratoga gage. Records at Arroyo Seco go back as far as 1906 and were used to supplement the information on the base stations used in the original regional frequency analysis. The analysis gave an equivalent length of record at the Los Gatos gage of over 35 years, with a correlation coefficient of .78 (fair correlation). Using the regional skewness of -0.6, the 1% flood peak was estimated at 10,800 cfs.

The location of the Los Gatos gage and the good reliability of the streamflow records enabled the gage to be used as a base station in the regional regression analysis. The 15 years of record were correlated in a matrix with data from 20 other streamflow stations with up to 60 years of record. This correlation enhanced the Los Gatos gage statistics to be equivalent to 55 years of record. Recorded and estimated annual maximums are compiled in Table 2-2. Using the mean and standard deviation calculated from the 20-station/60-year data matrix and the regional skewness of -.6, the 1% flood peak was estimated at 11,467 cfs.

Flood Estimates from Precipitation

Flood discharge estimated from rainfall data can be a useful adjunct to direct streamflow measurements. Such estimates require a valid watershed model for converting precipitation to discharge (e.g., calibrated watershed model, unit hydrograph).

In Santa Clara County the mean annual precipitation (M.A.P.) reflects well the integrated effects of availability of atmospheric moisture, of elevation and topography, and of efficiency of the orographic mechanism, which are significant parameters of storm rainfall. It was therefore possible to develop a relationship of storm volume vs. M.A.P. for different durations and frequency using data collected from rainfall stations in and around the County. The 24-hour rain with an exceedance frequency of 1% is used as the design storm.

TABLE 2-2

MAXIMUM ANNUAL PEAK FLOWS 1915 - 1975*
STREAM GAGE LOS GATOS CREEK @ LOS GATOS

Year	Peak	Year	
1915	529.Est.*	1946	1975.Est.
1916	7065. "	1947	731. "
1917	2739. "	1948	150. "
1918	1838. "	1949	1163. "
1919	817. "	1950	985. "
1920	1376. "	1951	5476. "
1921	3791. "	1952	5762. "
1922	5070. "	1953	1750. "
1923	736. "	1954	609. "
1924	805. "	1955	1009. "
1925	577. "	1956	14704. "
1926	2963. "	1957	678. "
1927	7017. "	1958	3837. "
1928	3026.Est.	1959	1069. "
1929	2542.Est.	1960	948. "
1930	2160.	1961	460. "
1931	221.	1962	1819. "
1932	3340.	1963	5958. "
1933	582.	1964	1356. "
1934	1080.	1965	2025. "
1935	1040.	1966	1136. "
1936	1310.	1967	4500. "
1937	5500.	1968	882. "
1938	4800.	1969	8230. "
1939	485.	1970	3521. "
1940	7110.	1971	1561. "
1941	4150.	1972	695. "
1942	2700.	1973	3380. "
1943	4610.	1974	1210. "
1944	1270.	1975	4311.Est.
1945	10476.Est.		

*Peak flow rates for 1915-1929 and 1945-1975 were estimated using multiple cross correlation with surroundings stations as part of 1976 Regional Regression Study. Flows estimated for years after 1950 assume there is no reservoir regulation.

The unit hydrograph theory was employed to convert the storm rainfall to discharge. Clark's synthetic unit hydrograph was used with the Corps of Engineers' 24-hour standard storm distribution and a 30% loss rate. It has been found that a 30% loss rate applied to the one percent storm closely approximates the one percent flood on adjacent watersheds in Santa Clara County. The results of this procedure are compiled in the flow summary Table 2-3. The peak flow rate at the stream gage site is 12,256 cfs.

Following is a summary of the preceding estimates for the 1% peak flow at the stream gage.

Record	n (Equivalent Years of Record)	Q 1% (cfs)
Recorded Annual Peaks	15	12,304
Correlation with Saratoga Gage	30	9,578
Correlation with Saratoga, Arroyo Seco Gage	35	10,800
Correlation with 20 Station/60-year Matrix	55	11,467
Rainfall Generated Peak	-	12,256

The recommended 1% peak flow value from the 1976 equations of 11,210 cfs (Table 2-6) agrees best with the matrix correlation giving the greatest number of equivalent years of record (11,467 cfs).

Special Consideration - Reservoir Levels

To determine the 1% flow on Los Gatos Creek, an item has been given special consideration; the initial storage levels in the reservoirs.

The reservoirs on Los Gatos Creek are operated as water conservation facilities but they do provide incidental flood

TABLE 2-3

LOS GATOS CREEK
RAINFALL GENERATED FLOWS
WITHOUT ANY RESERVOIRS

RUNOFF SUMMARY, AVERAGE FLOW

			PEAK	6-HOUR	24-HOUR	50-HOUR	AREA
	HYDROGRAPH AT	1	4312.	3572.	2280.	1131.	9.91
	ROUTED TO	2	4245.	3577.	2272.	1132.	9.91
	HYDROGRAPH AT	2	8255.	7678.	5090.	2776.	27.61
	ROUTED TO	2	8255.	7678.	5090.	2776.	27.61
@ Stream Gage	2 COMBINED	2	12256.	11114.	7298.	3908.	37.52
	ROUTED TO	3	12140.	11050.	7288.	3906.	37.52
	HYDROGRAPH AT	3	2298.	1795.	1074.	528.	6.46
	ROUTED TO	3	2298.	1795.	1074.	528.	6.46
	2 COMBINED	3	14108.	12757.	8298.	4434.	43.98
	ROUTED TO	4	14158.	12725.	8294.	4432.	43.98
	HYDROGRAPH AT	4	669.	483.	272.	131.	2.17
	ROUTED TO	4	669.	483.	272.	131.	2.17
@ Camden Avenue	2 COMBINED	4	14556.	13138.	8537.	4564.	46.15
	ROUTED TO	5	14556.	13115.	8529.	4562.	46.15
	HYDROGRAPH AT	5	460.	365.	234.	116.	1.58
	HYDROGRAPH AT	5	279.	214.	120.	58.	1.06
	2 COMBINED	5	739.	579.	354.	174.	2.64
	ROUTED TO	5	315.	314.	290.	174.	2.64
@ Highway 17	2 COMBINED	5	14861.	13419.	8817.	4736.	48.79
	ROUTED TO	6	14803.	13381.	8814.	4733.	48.79
	HYDROGRAPH AT	6	391.	320.	209.	105.	1.47
	HYDROGRAPH AT	6	249.	191.	107.	52.	0.98
	2 COMBINED	6	639.	509.	316.	157.	2.45
	ROUTED TO	6	288.	286.	266.	157.	2.45
@ Meridian Avenue	2 COMBINED	6	15080.	13663.	9080.	4891.	51.24
	ROUTED TO	7	15028.	13681.	9084.	4889.	51.24
	HYDROGRAPH AT	7	565.	457.	294.	147.	2.15
	HYDROGRAPH AT	7	346.	269.	148.	72.	1.44
	2 COMBINED	7	911.	725.	442.	219.	3.59
	ROUTED TO	7	414.	411.	383.	219.	3.59
@ Guadalupe River	2 COMBINED	7	15427.	14087.	9466.	5108.	54.83

protection since they might be less than full when a large storm occurs (the December 1955 flood is a good example when Lexington was 46% full). However, even a full reservoir will attenuate a flood peak to some degree.

The effect of a full Lexington Reservoir on the downstream flow rates is compiled in Table 2-4. A full reservoir reduces the inflow hydrograph by 20% from 11,200 cfs to less than 9,000 cfs.

Because there is a very good chance that a reservoir would not be full at the time the 1% design flow occurs, it was necessary to determine an initial reservoir level which would account for the compounded probabilities between the incoming flow and reservoir storage, and give a realistic value for an outflow which would have a 1% chance of occurring in any one year. The procedure followed was developed by the Corps of Engineers and is documented in the Corps of Engineers' Statistical Hydrology. The results for Lexington indicate that the initial reservoir storage should be 14,000 acre-feet, which is about 70 percent of capacity.

Lexington Reservoir has filled to spilling in 7 of the 23 years it has been operating. On the average, during the six months of November through April when large floods are most likely to occur, the reservoir is less than half full 80% of the time. On the average throughout the year, the reservoir is full only 10% of the time and this is generally only toward the latter part of the season. Elsman Reservoir was assumed to be always full.

With 14,000 acre-feet as the initial storage volume in Lexington, the outflow is 6,650 cfs. The downstream flow rates are as tabulated in Table 2-5.

TABLE 2-4
LOS GATOS CREEK
1976 REGIONAL REGRESSION EQUATIONS
LEXINGTON FULL 20,250 AF

RUNOFF SUMMARY, AVERAGE FLOW

			PEAK	6-HOUR	24-HOUR	50-HOUR	AREA
Inflow to Elsman	HYDROGRAPH AT	1	4113.	3139.	1977.	981.	9.91
Outflow from Elsman	ROUTED TO	1	3430.	3029.	1902.	980.	9.91
	ROUTED TO	2	3380.	3003.	1895.	980.	9.91
	HYDROGRAPH AT	2	7830.	6345.	4122.	2248.	27.61
Inflow to Lexington	ROUTED TO	2	7830.	6345.	4122.	2248.	27.61
Outfrom from Lexington	2 COMBINED	2	11210.	9347.	6016.	3227.	37.52
	ROUTED TO	2	8935.	8571.	5687.	3180.	37.52
	ROUTED TO	3	8942.	8568.	5670.	3162.	37.52
	HYDROGRAPH AT	3	2431.	1632.	951.	468.	6.46
	ROUTED TO	3	2431.	1632.	951.	468.	6.46
Inflow to Vasona	2 COMBINED	3	9932.	9526.	6405.	3630.	43.98
Outflow from Vasona	ROUTED TO	3	9922.	9510.	6404.	3623.	43.98
	ROUTED TO	4	9947.	9508.	6397.	3610.	43.98
	HYDROGRAPH AT	4	859.	490.	263.	127.	2.17
	ROUTED TO	4	859.	490.	263.	127.	2.17
@ Camden Avenue	2 COMBINED	4	10151.	9703.	6586.	3738.	46.15
	ROUTED TO	5	10134.	9698.	6587.	3729.	46.15
	HYDROGRAPH AT	5	460.	365.	234.	116.	1.58
	HYDROGRAPH AT	5	279.	214.	120.	58.	1.06
	2 COMBINED	5	739.	579.	354.	174.	2.64
	ROUTED TO	5	315.	314.	290.	174.	2.64
@ Highway 17	2 COMBINED	5	10449.	10011.	6855.	3903.	48.79
	ROUTED TO	6	10404.	10020.	6857.	3891.	48.79
	HYDROGRAPH AT	6	391.	320.	209.	105.	1.47
	HYDROGRAPH AT	6	249.	191.	107.	52.	0.98
	2 COMBINED	6	639.	509.	316.	157.	2.45
	ROUTED TO	6	288.	286.	266.	157.	2.45
@ Meridian Avenue	2 COMBINED	6	10692.	10306.	7101.	4049.	51.24
	ROUTED TO	7	10710.	10307.	7103.	4042.	51.24
	HYDROGRAPH AT	7	565.	457.	294.	147.	2.15
	HYDROGRAPH AT	7	346.	269.	148.	72.	1.44
	2 COMBINED	7	911.	725.	442.	219.	3.59
	ROUTED TO	7	414.	411.	383.	219.	3.59
@ Guadalupe River	2 COMBINED	7	11123.	10718.	7443.	4262.	54.83

TABLE 2-5
LOS GATOS CREEK
1976 REGIONAL REGRESSION EQUATIONS
COINCIDENT FREQUENCY RESERVOIR LEVEL - LEXINGTON AT 14,000 AF

RUNOFF SUMMARY, AVERAGE FLOW

			PEAK	6-HOUR	24-HOUR	50-HOUR	AREA
Inflow to Elsman	HYDROGRAPH AT	1	4113.	3139.	1977.	981.	9.91
Outflow from Elsman	ROUTED TO	1	3430.	3029.	1902.	980.	9.91
	ROUTED TO	2	3380.	3003.	1895.	980.	9.91
	HYDROGRAPH AT	2	7830.	6345.	4122.	2248.	27.61
	ROUTED TO	2	7830.	6345.	4122.	2248.	27.61
Inflow to Lexington	2 COMBINED	2	11210.	9347.	6016.	3227.	37.52
Outflow from Lexington	ROUTED TO	2	6646.	6168.	3335.	1668.	37.52
	ROUTED TO	3	6599.	6141.	3300.	1650.	37.52
	HYDROGRAPH AT	3	2431.	1632.	951.	468.	6.46
	ROUTED TO	3	2431.	1632.	951.	468.	6.46
	2 COMBINED	3	6992.	6519.	3646.	2118.	43.98
Inflow to Vasona	ROUTED TO	3	6982.	6473.	3643.	2110.	43.98
Outflow from Vasona	ROUTED TO	4	6989.	6448.	3639.	2098.	43.98
	HYDROGRAPH AT	4	859.	490.	263.	127.	2.17
	ROUTED TO	4	859.	490.	263.	127.	2.17
@ Camden Avenue	2 COMBINED	4	7020.	6474.	3764.	2225.	46.15
	ROUTED TO	5	6985.	6499.	3761.	2216.	46.15
	HYDROGRAPH AT	5	460.	365.	234.	116.	1.58
	HYDROGRAPH AT	5	279.	214.	120.	58.	1.06
	2 COMBINED	5	739.	579.	354.	174.	2.64
	ROUTED TO	5	315.	314.	290.	174.	2.64
@ Highway 17	2 COMBINED	5	7296.	6801.	3981.	2390.	48.79
	ROUTED TO	6	7287.	6801.	3977.	2379.	48.79
	HYDROGRAPH AT	6	391.	320.	209.	105.	1.47
	HYDROGRAPH AT	6	249.	191.	107.	52.	0.98
	2 COMBINED	6	639.	509.	316.	157.	2.45
	ROUTED TO	6	288.	286.	266.	157.	2.45
@ Meridian Avenue	2 COMBINED	6	7569.	7079.	4180.	2536.	51.24
	ROUTED TO	7	7574.	7066.	4179.	2530.	51.24
	HYDROGRAPH AT	7	565.	457.	294.	147.	2.15
	HYDROGRAPH AT	7	346.	269.	148.	72.	1.44
	2 COMBINED	7	911.	725.	442.	219.	3.59
	ROUTED TO	7	414.	411.	383.	219.	3.59
@ Guadalupe River	2 COMBINED	7	7978.	7465.	4462.	2749.	54.83

The series of maximum annual flows at SCVWD #67 for the years after the construction of Lexington Reservoir is a combination of unregulated spill flows and controlled releases. This series is non-random and non-homogeneous and therefore any statistical analysis would be improper and inconclusive. However, there is some statistical justification for analyzing a partial duration series composed of all unregulated spill flows. Partial duration series and maximum annual series are essentially equal at the upper extremes of the frequency curves. Figure 2-3 illustrates the frequency curve resulting from the partial duration analysis. This curve could be interpreted as inherently reflecting the effects of the reservoir on the frequency curve. It estimates the 1% flood as 6,400 cfs. This compares with 6,650 cfs as determined from the incidental storage analysis.

OTHER STUDIES - PAST AND PRESENT

The hydrology of Los Gatos Creek has been studied several times in the past. The value currently listed in the 1972 Manual of Design Flows is from a 1970 study based on the application of outdated regional regression equations and is:

Los Gatos Creek	Upstream from Guadalupe River 54.83 square miles, 14,000 cfs

Several observations can be made about this value; for example, thirty percent of the total drainage area is below Lexington Dam yet the 14,000 cfs figure does not reflect any local inflow. The inflow to Lexington Reservoir required to produce the 14,000 cfs downstream would be 18,000 cfs, a value at least 50 percent higher than indicated by flood flow frequency analyses in the present study. The reservoir capacity in the 1970 study was

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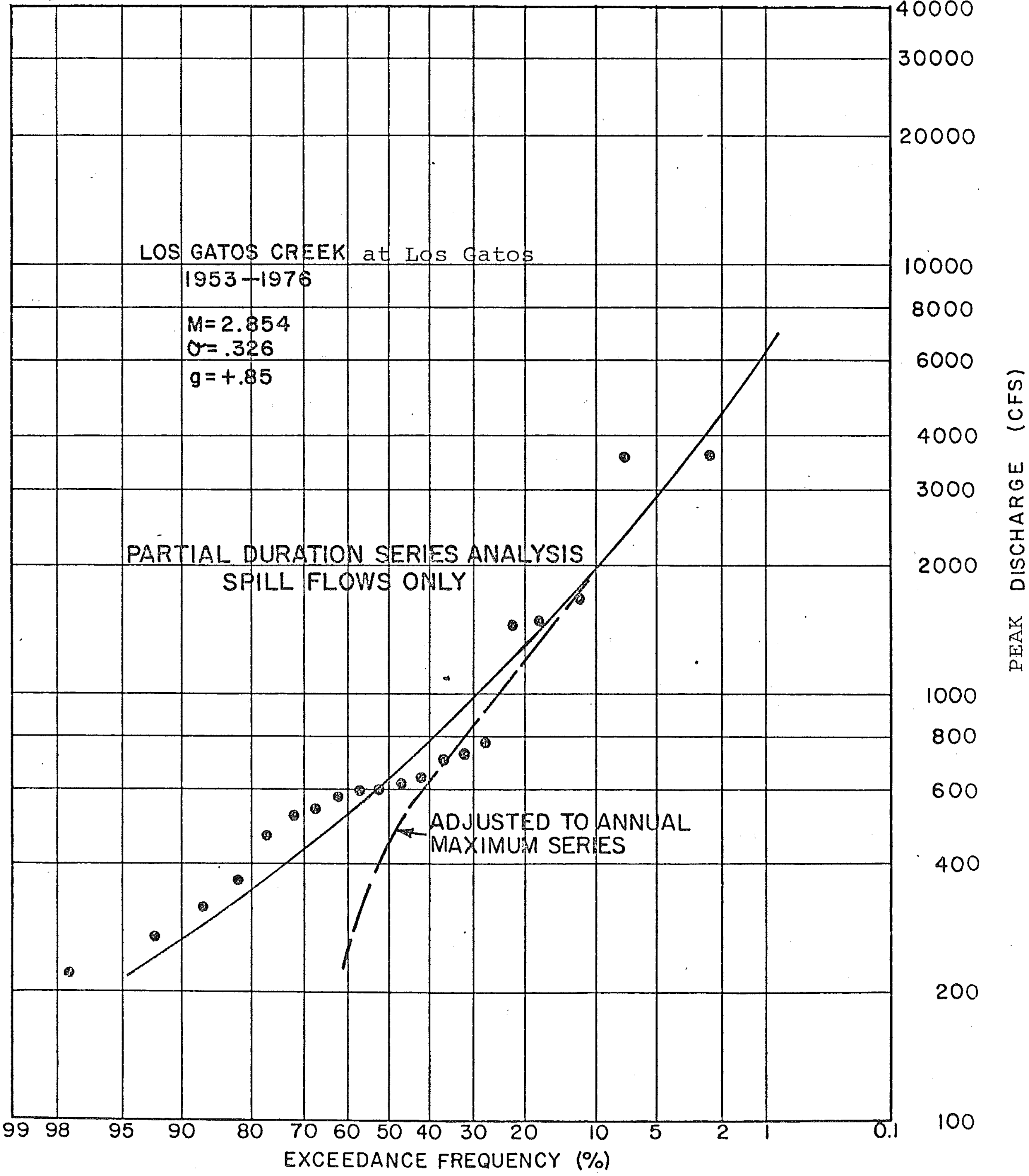


Data are regulated by Lexington Reservoir

FIGURE 2-3

assumed to be full, a reasonably conservative approach if there is not sufficient information for a more rigorous analysis.

The past regional equations as developed in 1972 (third generation equations) have been used until revised by the 1976 equations. The U. S. Geological Survey has developed its own set of regression equations for the San Francisco Bay Region. These equations were used to develop the USGS flow frequency curve shown in Figure 2-3. The log Pearson Type III frequency curve computed from the District's 20 station/60-year matrix is included for reference in the figure also. How well each set of equations represents the Los Gatos Basin is shown graphically in Figure 2-4 where each flow frequency curve is plotted in comparison with the recorded data at the Los Gatos stream gage. The comparison of the curves demonstrates the high applicability of the 1976 Regional Equations to the Los Gatos Creek watershed.

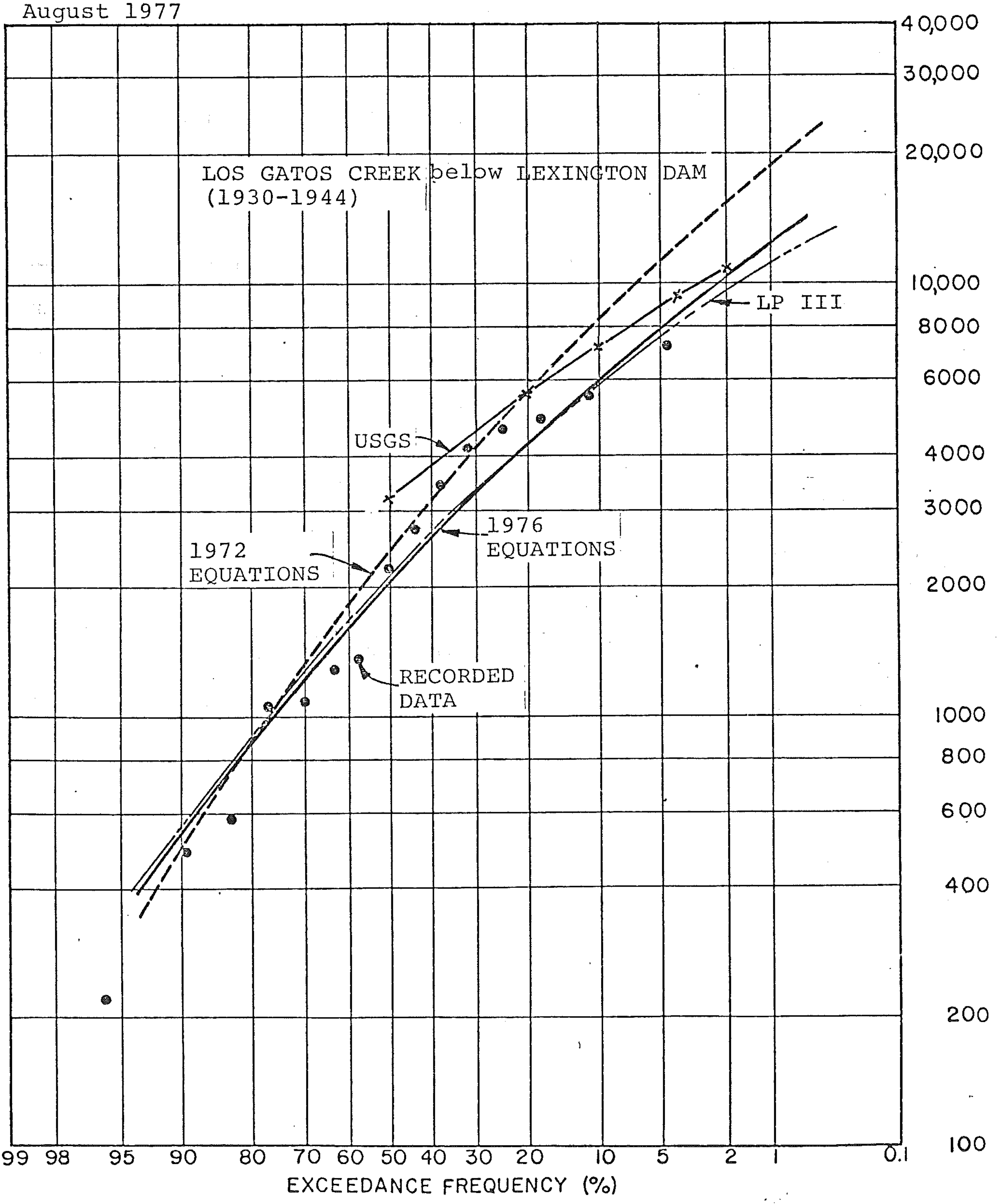
CONCLUSION

This report is the summary of all the work completed in the study of the Los Gatos Creek hydrology. The investigation is complete and thorough and has produced excellent results.

The flow rates have been computed from the 1976 Regional Regression Equations; checked against statistical analysis of systematic streamflow records; compared with hydrologically similar watersheds; generated from rainfall; and contrasted with past studies.

The application of the 1976 Regional Equations compares quite favorably with those developed by the U.S. Geological Survey. Also in the January 1972 FPI study on the Guadalupe River by the

August 1977



Data without regulation

FIGURE 2-4

Corps of Engineers the Los Gatos Creek contribution at the Guadalupe River confluence was 7,300 cfs while our recommended design flows at this point is 7,980 cfs. All evidence was found to be mutually supportive.

The coincidental frequency reservoir storage of 14,000 acre-feet in Lexington Reservoir was determined following the procedure outlined in the Corps of Engineers' Statistical Hydrology.

Therefore, after careful consideration and deliberation of all available information, it is recommended that the flows derived using the 1976 Regional Regression Equations and a coincidental frequency reservoir level be used for design purposes. These values represent the best possible alternative under present circumstances. The recommended 1% design flows are summarized in Table 2-6 along with the 10% design flows in Table 2-7. The values in these tables should be rounded up to significant figures. The flow frequency curve is shown in Figure 2-5.

TABLE 2-6

LOS GATOS CREEK
RECOMMENDED DESIGN FLOWS - 1% FLOOD

RUNOFF SUMMARY, AVERAGE FLOW

			PEAK	6-HOUR	24-HOUR	50-HOUR	AREA
Inflow to Elsman	HYDROGRAPH AT	1	4113.	3139.	1977.	981.	9.91
Outflow from Elsman	ROUTED TO	1	3430.	3029.	1902.	980.	9.91
	ROUTED TO	2	3380.	3003.	1895.	980.	9.91
	HYDROGRAPH AT	2	7830.	6345.	4122.	2248.	27.61
	ROUTED TO	2	7830.	6345.	4122.	2248.	27.61
Inflow to Lexington	2 COMBINED	2	11210.	9347.	6016.	3227.	37.52
Outflow from Lexington	ROUTED TO	2	6646.	6168.	3335.	1668.	37.52
	ROUTED TO	3	6599.	6141.	3300.	1650.	37.52
	HYDROGRAPH AT	3	2431.	1632.	951.	468.	6.46
	ROUTED TO	3	2431.	1632.	951.	468.	6.46
Inflow to Vasona	2 COMBINED	3	6992.	6519.	3646.	2118.	43.98
Outflow from Vasona	ROUTED TO	3	6982.	6473.	3643.	2110.	43.98
	ROUTED TO	4	6989.	6448.	3639.	2098.	43.98
	HYDROGRAPH AT	4	859.	490.	263.	127.	2.17
	ROUTED TO	4	859.	490.	263.	127.	2.17
@ Camden Avenue	2 COMBINED	4	7020.	6474.	3764.	2225.	46.15
	ROUTED TO	5	6985.	6499.	3761.	2216.	46.15
	HYDROGRAPH AT	5	460.	365.	234.	116.	1.58
	HYDROGRAPH AT	5	279.	214.	120.	58.	1.06
	2 COMBINED	5	739.	579.	354.	174.	2.64
	ROUTED TO	5	315.	314.	290.	174.	2.64
@ Highway 17	2 COMBINED	5	7296.	6801.	3981.	2390.	48.79
	ROUTED TO	6	7287.	6801.	3977.	2379.	48.79
	HYDROGRAPH AT	6	391.	320.	209.	105.	1.47
	HYDROGRAPH AT	6	249.	191.	107.	52.	0.98
	2 COMBINED	6	639.	509.	316.	157.	2.45
	ROUTED TO	6	288.	286.	266.	157.	2.45
@ Meridian Avenue	2 COMBINED	6	7569.	7079.	4180.	2536.	51.24
	ROUTED TO	7	7574.	7066.	4179.	2530.	51.24
	HYDROGRAPH AT	7	565.	457.	294.	147.	2.15
	HYDROGRAPH AT	7	346.	269.	148.	72.	1.44
	2 COMBINED	7	911.	725.	442.	219.	3.59
	ROUTED TO	7	414.	411.	383.	219.	3.59
@ Guadalupe River	2 COMBINED	7	7978.	7465.	4462.	2749.	54.83

TABLE 2-7

LOS GATOS CREEK
RECOMMENDED DESIGN FLOWS - 10% FLOOD

RUNOFF SUMMARY, AVERAGE FLOW

			PEAK	6-HOUR	24-HOUR	50-HOUR	AREA
Inflow to Elsman	HYDROGRAPH AT	1	2384.	2074.	1153.	563.	9.91
Outflow from Elsman	ROUTED TO	1	2122.	1920.	1095.	562.	9.91
	ROUTED TO	2	2100.	1906.	1089.	561.	9.91
	HYDROGRAPH AT	2	4196.	3781.	2250.	1206.	27.61
	ROUTED TO	2	4196.	3781.	2250.	1206.	27.61
Inflow to Lexington	2 COMBINED	2	6263.	5687.	3337.	1767.	37.52
Outflow from Lexington	ROUTED TO	2	1611.	1512.	952.	466.	37.52
	ROUTED TO	3	1563.	1484.	935.	454.	37.52
	HYDROGRAPH AT	3	1190.	923.	473.	230.	6.46
	ROUTED TO	3	1190.	923.	473.	230.	6.46
Inflow to Vasona	2 COMBINED	3	1569.	1487.	1019.	684.	43.98
Outflow from Vasona	ROUTED TO	3	1550.	1472.	1016.	679.	43.98
	ROUTED TO	4	1540.	1467.	1014.	670.	43.98
	HYDROGRAPH AT	4	378.	242.	116.	56.	2.17
	ROUTED TO	4	378.	242.	116.	56.	2.17
@ Camden Avenue	2 COMBINED	4	1540.	1467.	1066.	725.	46.15
	ROUTED TO	5	1529.	1458.	1064.	718.	46.15
	HYDROGRAPH AT	5	306.	238.	147.	72.	1.58
	HYDROGRAPH AT	5	172.	126.	61.	29.	1.06
	2 COMBINED	5	477.	363.	207.	102.	2.64
	ROUTED TO	5	276.	274.	205.	102.	2.64
@ Highway 17	2 COMBINED	5	1570.	1459.	1178.	820.	48.79
	ROUTED TO	6	1532.	1456.	1177.	810.	48.79
	HYDROGRAPH AT	6	258.	207.	131.	66.	1.47
	HYDROGRAPH AT	6	152.	111.	54.	26.	0.98
	2 COMBINED	6	410.	318.	184.	91.	2.45
	ROUTED TO	6	254.	253.	183.	91.	2.45
@ Meridian Avenue	2 COMBINED	6	1786.	1615.	1287.	901.	51.24
	ROUTED TO	7	1794.	1614.	1286.	896.	51.24
	HYDROGRAPH AT	7	366.	293.	183.	91.	2.15
	HYDROGRAPH AT	7	205.	153.	72.	35.	1.44
	2 COMBINED	7	571.	445.	255.	126.	3.59
	ROUTED TO	7	370.	368.	254.	126.	3.59
@ Guadalupe River	2 COMBINED	7	2165.	1982.	1448.	1022.	54.83

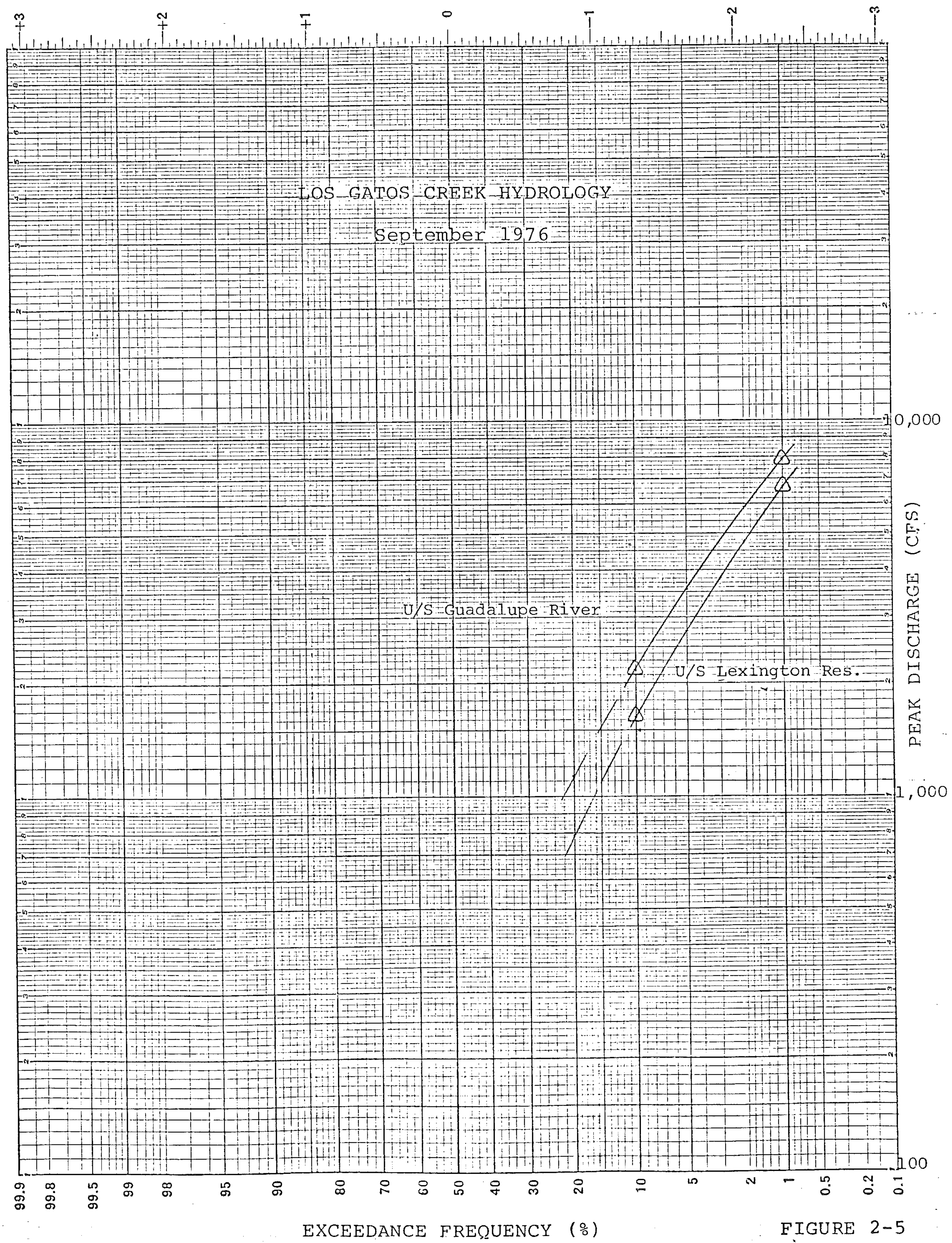

LOS GATOS CREEK HYDROLOGY
September 1976
U/S Guadalupe River
U/S Lexington Res.
PEAK DISCHARGE (CFS)
10,000
1,000
100
EXCEEDANCE FREQUENCY (%)
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
+3
+2
+1
0
-1
-2
-3

FIGURE 2-5

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